MINING ENGINEERING

JULY 1950

20 Years of Continuous Service

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THE LEYDEN LIGNITE COMPANY

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April 1st, 1950

A. R. Wilfley & Sons,
Denham Building,
Denver, Colorado.

Gentlemen:

I understand that your Mr. Elmer Wilfley is out of the City and upon his return I wish you would show him this letter and express to him our appreciation of the fact that this pump was l[illegible] to the Leyden Lignite Com-pany over twenty years ago and it has been in continuous service ever since with no repairs - a remarkable achieve-ment.

Yours very truly,

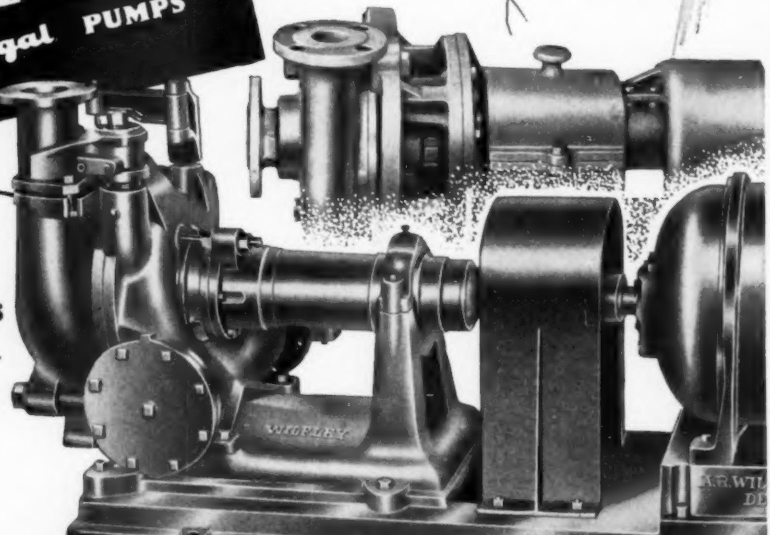
THE LEYDEN LIGNITE COMPANY,

BY J. Nash
President and General Manager.

Dependability, efficiency and cost-saving economy are built-in features of *every* WILFLEY Sand and Acid Pump. Individual engineering on every application. Write or wire for complete details.

Buy WILFLEY for Cost-Saving Performance

WILFLEY centrifugal PUMPS



A. R. WILFLEY & SONS
INC.
DENVER, COLORADO, U. S. A.

New York Office:
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MINING ENGINEERING

Incorporating Mining and Metallurgy, Mining Technology and Coal Technology

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FEATURES

ARTICLES

TRANSACTIONS

Cover photo: A Goodman duckbill is shown loading coal in pillar recovery operations in the Hudson Coal Co.'s mine. See p. 762 for more information on mechanization in the anthracite fields. *Photo courtesy the Goodman Mfg. Co.*

Construction

EXAMINE THESE FEATURES— PROVE TO YOURSELF THAT HYDROCONE CRUSHERS WILL DO A JOB OF FINE REDUCTION CRUSHING FOR YOU!

GOOD NEWS for crushing men! Now — you can meet fine reduction crushing requirements in a new, wider range of capacities. The line of *Hydrocone* gyratory crushers has been expanded by A-C to include sizes up to 84-in. diameter cone with a maximum receiving opening of 17-in.

With hydraulic product size control you can change product size *instantly*. Push-button operation on larger *Hydrocone* crushers; hand crank control on the smaller machines. No tools required.

Hydrocone crushers are available with fine, intermediate or coarse crushing chambers . . . offer a capacity range of 10 to 1000 tons per hour. The A-C representative in your area can give you more facts on this expanded line. A-3098

ALLIS-CHALMERS, 971A SO. 70 ST.
MILWAUKEE, WIS.

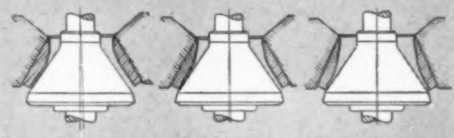
WOBBLE PLATE FEEDER distributes feed evenly . . . standard equipment on crushers with fine crushing chambers — can be supplied on others as well.

SLEEVE TYPE spider bearing is readily replaceable . . . greatly simplifies maintenance. Used on larger size *Hydrocone* crushers. Ball and socket type spider bearing supplied crusher sizes up to 48-in. In both types, lubricant is retained by an efficient seal enclosing the main shaft.

ONE-PIECE outer crushing surface is a concave ring cast of mantalloy. Necessity of zincing or clamping the concave ring in place is eliminated by ground-to-fit finish on the outer surface and the use of an effective self-locking device.

ONE-PIECE inner crushing surface, like the concave ring, is cast of mantalloy, designed for long wear. Complete contact of the ground inner surface with the steel head center eliminates zincing in all but the largest sizes. The mantle is held tightly in place by the self-locking head nut.

HIGH CAPACITY crushing chamber of any of the three standard types is designed to assure a continuous, uniform product. The shape of the mantle and concave ring, and the large adjustment range available, results in maximum life and minimum scrap when replacing parts. Special crushing chambers also available for special applications.



FINE CRUSHING CHAMBER — INTERMEDIATE CRUSHING CHAMBER — COARSE CRUSHING CHAMBER

THREE-PIECE step bearing supports the main shaft on the hydraulic piston. Designed to withstand crushing pressures much greater than those encountered in actual service.

FULLY AUTOMATIC lubricating system consists of storage tank, pressure type filter, condenser type cooler, and motor driven oil pump. Flow and temperature switches in the oil line protect the crusher.

The 84-in. *Hydrocone* gyratory crusher has a 17-in. feed opening.

Grand Valley Tunnel Completed in Record Time

THE DAILY SENTINEL

VOL. LVII GRAND JUNCTION, COLORADO, THURSDAY EVENING, APRIL 27, 1950 NO. 187

2,240-Foot Bore Being Completed Over Month Ahead of Schedule

Cleanup Work Already Underway So First Water Can Be Turned In As Soon As Possible; Speed Record Set In Both Drilling and Contracts

A 2,240-foot bypass around that portion of the Grand Valley project tunnel No. 3 which closed completely March 8 was holed thru at 12:12 a. m. today.

Cleanup work was started immediately and it is ex- pected the first water of 1950 below the tunnel May 1 or sho

The 1,500 project farmers in this arid climate their near land would have been unpro 6,000 acres of peach trees

thru, so in you go.

It's a clean-appearing bore 13 feet in diameter. You can tell where each shot was set off, since the bore is slightly wider at the center of the blast. Crews are still hauling muck out from the previous blast as you go in. You find [redacted] and [redacted] of the bureau watching crews load out four-yard ore cars every 40 seconds. [redacted]

Grand Valley Tunnel has been holed through with more than a month to spare in the 70-day contract. The 2240 foot tunnel is to be finished inside 11′ x 11½′ horseshoe and the excavated section is approximately two feet greater in each dimension.

When the daily advance figures are available, there is a probability that a new world's speed record will have been established for this size tunnel.

Dependable Eimco RockerShovels used in both ends of the bore helped speed the advance by moving the large quantities of broken rock quickly and efficiently.

Eimco RockerShovels are built to load the customers car faster and cheaper. There is a RockerShovel to fit your needs. Write for more information.

EIMCO

THE EIMCO CORPORATION

The World's Largest Manufacturers of Underground Rock Loading Machines

EXECUTIVE OFFICES AND FACTORIES — SALT LAKE CITY 8, UTAH, U. S. A.

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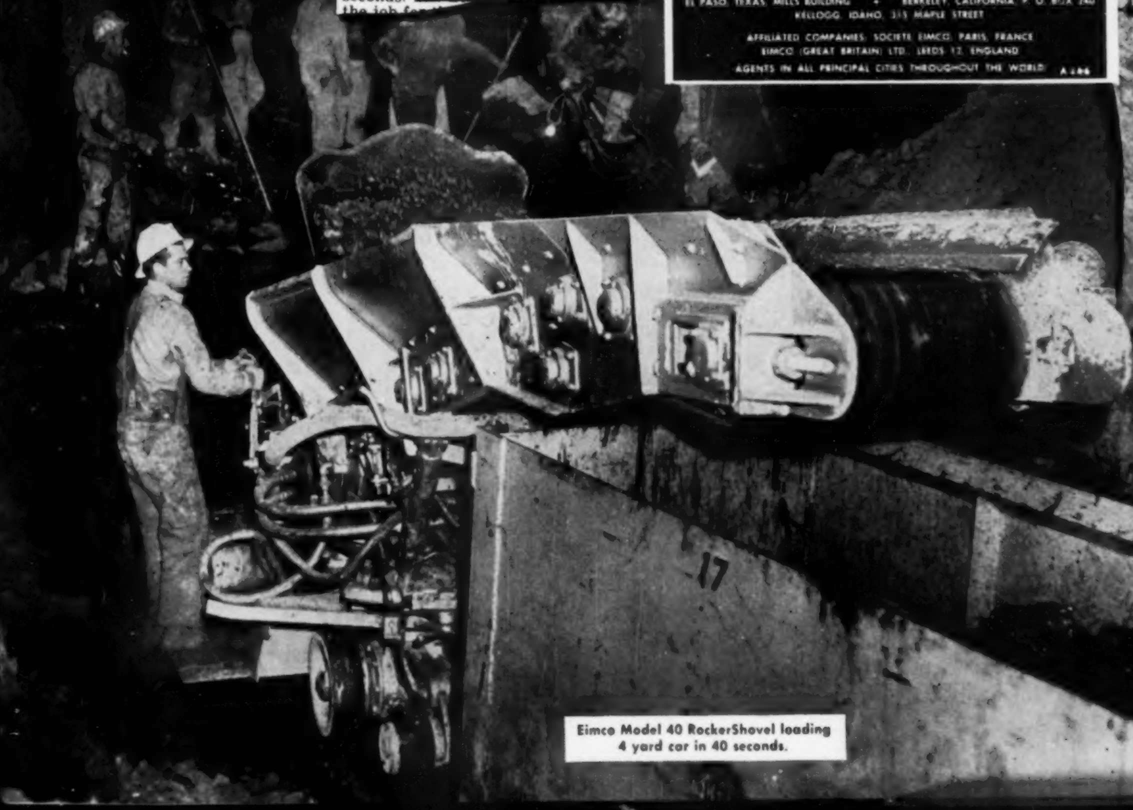
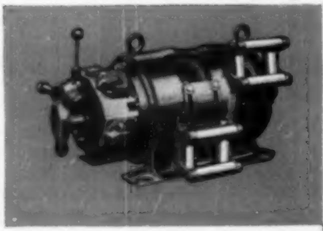
EIMCO (GREAT BRITAIN) LTD., LEEDS 12, ENGLAND

AGENTS IN ALL PRINCIPAL CITIES THROUGHOUT THE WORLD A-186



Eimco Model 40 RockerShovel loading 4 yard car in 40 seconds.

Talk about "lugging power"



Gardner-Denver Airslushers are made in three sizes, with rated rope pull of 1100, 2000 and 2500 pounds.

—and you're talking about the GARDNER-DENVER AIRSLUSHER!

The Gardner-Denver Airslusher knuckles down and lugs a pay load every trip — hurries the empty scraper back for another load. It's powered by the famous Gardner-Denver 5-cylinder air motor that develops high torque at any speed — assures maximum speed and power in either direction.

Other outstanding Airslusher advantages include:

- **Finger-tip throttle control**
- **Free-wheeling clutch**
- **Fewer parts for easier maintenance**
- **Slips through small raises**
- **Saves air—never idles between trips**

Widely used on shaft mucking rigs—*the Gardner-Denver HMS Hoist. Designed for one-man operation. Positive safety lock. Supplied with or without automatic brake.*

Write today for complete information on Gardner-Denver Airslushers or the HMS Shaft Mucking Hoist.

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Engineering Societies Service

THE following employment items are made available to AIME members on a non-profit basis by the Engineering Societies Personnel Service, Inc., operating in co-operation with the Four Founder Societies. Local offices of the Personnel Service are at 8 W. 40th St., **New York 18;** 100 Farnsworth Ave., **Detroit;** 57 Post St., **San Francisco;** 84 E. Randolph St., **Chicago 1.** Applicants should address all mail to the proper key numbers in care of the New York Office and include 6¢ in stamps for forwarding and returning application. The applicant agrees, if placed in a position by means of the Service to pay the placement fee listed by the Service. AIME members may secure a weekly bulletin of positions available for $3.50 a quarter or $12 a year.

McKINLESS NEW DETROIT MANAGER

The Engineering Societies Personnel Service, Inc. announces the appointment of Lt. Col. Frank McKinless as manager of its Detroit office. Col. McKinless is a graduate of the Colorado School of Mines with over 25 years of experience covering the design, production, sales and management fields. He served with the Marine Corps in both world wars and headed Personnel Procurement for the Marines in the New York District during all of World War II.

Positions Open

Assistant, Associate or Full Professor to teach and do research work in mineral dressing, particularly in the field of coal preparation. Will be chief of division. Salary, $6000 plus retirement, insurance and hospitalization benefit and plans. Location, East. Y3611-R6484.

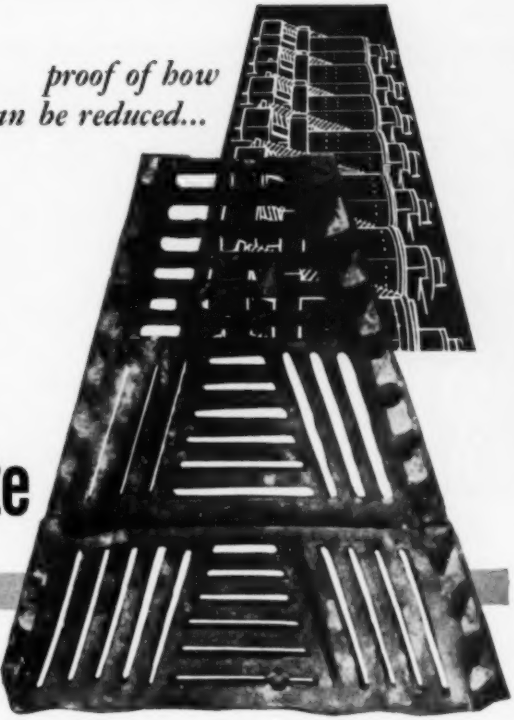
Geophysicist, young, with some field experience preferably including seismic methods, for mining work. Must be willing to travel extensively, both domestic and foreign. Salary, $3000-$4500 a year dependent on training and experience, plus expenses when away from New York headquarters. Y3603.

Mining Engineer, graduate, with underground mining and supervisory experience, to act as shift boss, for underground hard ore mine using shrinkage and sub-level stoping. Salary, $3600-$4200 a year. Location, New Jersey. Y3132.

Mining Consultant for central staff position, with at least ten

(*Continued on P. 748*)

proof of how milling costs can be reduced...



this AMSCO® Grate has milled 193,797 tons

An actual example of how AMSCO Grates last longer, reduce shutdowns and increase milling profits.

Equally Big Savings On Liners, Too!
Recent production figures on Amsco double-wave Liners in a mill grinding copper ore: 667,308 tons ground . . . at a liner cost of about a half-cent per ton! *It will pay you to investigate the long, low-cost service of Amsco Liners!*

Find out more about Amsco Liners and Grates

Be sure to ask for a copy of Bulletin 449-ML. Describes the characteristics of Amsco ball mill alloys; gives additional facts on dollar-saving installations. Free copy on request.

Here's an actual photograph that proves an important, profit-building point to users of ball mill equipment . . . *the real cost of liners and grates is the actual service cost.*

This Amsco grate has milled 193,797 tons . . . compared with just 113,000 tons for a previously used hardened steel grate which ran under identical conditions. And, during this period of 72% greater tonnage milled, *the Amsco grate required no down-time for repair.* The previously used grate started to crack at 50,000 tons—required many shutdowns for plugging holes.

Because of heavy impact, this particular Amsco Grate was made of austenitic chromium-manganese steel—one of three Amsco alloys developed for specific conditions of impact and/or abrasion. These Amsco liner and grate alloys can result in big savings on milling costs. Amsco Engineers are fully qualified to make alloy recommendations based on your operating conditions—*write today for the name of the Amsco engineer nearest you.*

AMERICAN **Brake Shoe** COMPANY

AMERICAN MANGANESE STEEL DIVISION
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Other Plants: New Castle, Del., Denver, Oakland, Cal., Los Angeles, St. Louis. In Canada: Joliette Steel Division, Joliette, Que.

years' experience in management and direction of strip coal mining. Should have ability to purchase, plan, direct maintenance, etc., for nineteen mines. Salary, $15,000-$20,000 a year. Headquarters, New York, N. Y. Y3117.

Mining Engineer familiar with foreign ores and minerals, for export-import house. Location, New York, N. Y. Y3106.

Safety Engineer, under 40, with experience in safety work at mines, and experience in underground mines. Must be able to speak Spanish fluently. Must go single status for six months. Salary, $3600-$5328 a year, plus traveling expenses. Location, Cuba. Y3094.

Placer Engineer, 35-50, to assist chief engineer on development gold placer fields. Prefer man experienced in drag-line washing plant operations, underground mining of dry stream beds, diversion of streams, construction of reservoirs, flumes and pipe lines. Three-year contract. Salary, $7,000-$8,500 a year, tax exempt. Location, Ethiopia, temperate climate, elevation 5,000 feet. Y35556-S.

Shift Boss with Latin American experience preferred and knowledge of Spanish essential. Salary, $3,300 a year. Location Colombia, S. A. Y3587.

Men Available

Geologist, B.S. Desirous of gaining experience any phase of the field. All other factors and location immaterial. M-554.

Mine Superintendent, B.Sc. Min. Eng. 40, married, two children. Fluent French. Thirteen years' supervision and operation, small and large copper, zinc, gold, iron mines. Four years' mining Engineering, costs, mining construction. Employee training. Can produce tonnage and lower mining costs. Excellent record and references. Domestic, foreign. Available 30 days. M-556.

Mining Engineer, 37, married. Fourteen years' progressive mining and construction experience. Ability to perform work of greater than ordinary difficulty under only very general supervision. Prefer Metropolitan New York Area. M-557.

Letters to the Editor

Developments in Iran

(This is a discussion of the article by J. R. Lotz, "Developments in Iran", which appears on P. 770 of this issue.)

IN presenting the general features of Iran's Seven-Year Plan, Mr. Lotz has shown us what a financially sound but backward country can do on its own account, with its own resources, for its own benefit. It is an excellent precedent which might well be applied to underdeveloped countries in other parts of the world. As Mr. Lotz points out, the welfare of Iran is of particular interest to American business and security, as by establishing better living conditions and giving more employment for its 17 million inhabitants the threat of communism will be greatly reduced.

The present Shah Mahammed Resa Shah Pahlair, is to be complimented on having initiated such an all inclusive plan and the Overseas Consultants Inc., on the thoroughness of its studies and recommendations. However considerable resistance to this plan to increase production, improve methods of farming and build up industries, has come from the ruling class of wealthy families and from the conservative land owners, who are satisfied with their antiquated methods and hesitate to introduce changes.

Mr. Lotz shows step by step how the survey was conducted, its feasibility and how its objectives can be reached without undue burden on the people and economy of the country. In all they have 35 carefully selected specialists on the resident staff of consultants in Iran, cooperating with the local government departments.

As to the industries Mr. Lotz states that most of these are government owned and operated inefficiently, as a far greater number of persons are employed than necessary and the per capita output is very low. One of the strongest recommendations of Overseas Consultants Inc. to the Iran Government is the transfer of Government owned industrial and mining enterprises to private ownership. This of course will require the government to establish laws as well as to make loans to encourage financing of these industries by private investors.

Besides the large resources of petroleum there are small copper, lead, coal and iron mines and known deposits of manganese, chromite, antimony and gold and certain nonmetallics, which if developed might become important producers for domestic use as well as for export. Overseas Consultants Inc. are confident that the spirit and intelligence of the Iranian people and those in charge with the implementation of the Plan will see it through and make it a lasting success.

Our Government would do well to consider engaging private firms of efficient consultants to cooperate with local governments of the backward underdeveloped countries in the establishment of plans to build up their industries through private enterprise, rather than under government control. By such a procedure with the aid of the Point IV proposal, the funds to be appropriated by the United States and the local governments would be used effectively and would go farther in improving the living standards in the underdeveloped countries.

Charles Will Wright

(Continued on page 749)

National Safety Competition Winners Announced by USBM

CLIMAXING the twenty-fifth anniversary of the National Safety Competition, the country's mineral industries attained in 1949 the best safety record in the history of the contest, the U. S. Bureau of Mines has announced.

In naming the silver anniversary winners of the coveted Sentinels of Safety trophies to the plants that achieved top honors in safety, the Bureau of Mines reported that 202 mines and quarries had injury-free records last year.

The 1949 winners of the Sentinels of Safety trophies are:

Anthracite Mines: Stevens Shaft Mine, Kehoe-Berge Coal Co., Exeter, Pa.

Bituminous Coal Mines: Reliance No. 7 Mine, The Union Pacific Coal Company, Reliance, Wyoming.

Metal Mines: No. 2 Mine, American Zinc Company of Tennessee, Mascot, Tenn.

Nonmetallic Mines: Bellefonte Mine, National Gypsum Company, Bellefonte, Pa.

Open-Pit Mines: Embarrass Mine, Pickands Mather & Company, Biwabik, Minn.

Quarries: Dolonah Quarry, Tennessee Coal, Iron, and Railroad Company, Bessemer, Ala.

The National Safety Competition was started in 1925 by the Bureau of Mines upon the recommendation of former President Herbert Hoover, then serving as Secretary of Commerce. In commending the 1949 winners Mr. Hoover states:

"I have never ceased to be proud of the National Safety Competition ever since I had a hand in the matter twenty-five years ago. The annual trophy has given mark and distinction to the winners. But of even more importance is the stimulation the award has given to accomplishment in safety. I consider it a great privilege to congratulate each of its winners. You have done an outstanding service to your fellow workers."

Beginning this month mineral operations with the best safety records in each of the six groups in the competition will receive national recognition as leaders in mine and quarry safety. The 1949 winners achieving top safety honors in their respective groups will be awarded bronze Sentinels of Safety trophies and the Sentinel of Safety flags by The Explosives Engineer magazine. An individual Certificate of Achievement of Safety will be presented by the Bureau of Mines to each man in the winning plants.

Letters to the Editor

WE of the Fairbanks Department of the United States Smelting Refining and Mining Company have read with much interest your editorial in the March issue entitled "Engineers Training Plan", as we, in cooperation with the University of Alaska, have had a similar plan in operation since 1948. Our plan, however, is based on pre-graduation training instead of the post-graduate training provided for by the Ontario plan.

The pre-graduation feature is made advantageous by the long summer vacation of the U. of A. where winter and spring vacations are cut to a minimum and the summer vacation extends from about May 15 to September 15. A very large percentage of the students at the University are self-supporting and the academic year, while of equal length to that of "stateside" institutions, has been condensed to provide the longest possible earning season.

The operations of the U. S. S. R. and M. Co. here are confined to placer mining, mostly by dredging, but as a necessary part of this operation, churn drill prospecting, removal of overburden by hydraulicking and thawing of frozen gravel is carried on and these phases, together with the operation of a large power plant, shops and warehouse, enabled us to set up a three year training plan which gives each participant about 40 days training in nine different classes of work. It is not expected that anyone can become an expert in this short time, but he acquires a fair amount of "know how" and is encouraged to consult with his superintendents and foremen to "know why."

The plan is open to all engineering students of the University, with three men being chosen each year on the basis of scholarship and general ability. Each is assigned to a different job at the beginning of the season, rotating on forty day periods. All are paid at the regular rate for the job classification and at the end of the first and second seasons are invited to submit an essay covering some phase of their work, a $50.00 prize being awarded for the essay chosen. All participants completing the three year course are given a certificate and a cash award of $250.00. No promise of future employment is made, but it is emphasized that participants who complete the course satisfactorily will be given strong consideration for openings in the permanent force after graduation.

The plan is yet too young to have furnished concrete evidence of its value, but we are well pleased with the results so far and expect even better results in the future. Two of the original three men starting the course are beginning their final season this spring and they, as well as ourselves, feel that it has been well worth while.

R. H. Ogburn
Assistant General Manager

More on "Cerro Bolivar"

. . . You pass over the ore deposits at Steep Rock Lake and at Michipicoten in such a casual manner that I can only assume that you lack information on recent developments in these areas.

The Steep Rock deposits are high-grade hydrated hematites occurring as long, almost vertical, lenses of ore. We have outlined a total length of over 11,000 ft of ore; this length is only limited as yet by the amount of exploration carried out. Average width is close to 300 ft. The ore bodies have been well explored to a depth of 500 ft into bedrock and ore intersections have been obtained up to 1100 ft below the outcrop.

(Continued on P. 750)

Letters

(Continued from P. 749)

Steep Rock presently estimates 72 million tons of proven and probable ore, but this takes into account only two of the ore bodies and these for a depth of about 450 ft into bedrock only. Recent exploration leads me to believe that we will develop more than 300 million tons of direct shipping iron ore in the first 1000 ft of depth into bedrock.

Steep Rock is commencing stripping and underground development to expand its present 1,200,000 ton annual production to 4 million tons. Inland Steel Co. has had "highly satisfactory" results in their first winter's exploration and should they take up their lease would produce in the vicinity of 3 million tons annually.

I do not have detailed information on the properties in the Michipicoten area but believe the siderite deposits of the area, by sintering and by sink float followed by sintering, will be capable of producing 3 million tons of ore annually for many years to come.

It is likely that in ten years' time, Ontario will be producing more than 10,000,000 tons of iron ore annually, and will be able to sustain this rate for somewhere in the vicinity of one hundred years. . . .

Steep Rock Iron Mines Limited
W. Samuel
Consulting Engineer

Engineering Education

I would like to take this opportunity to express agreement with Arthur F. Taggart in his article "A New Way of Educating Engineers" in Mining Engineering, April 1950. I have myself been employed by a number of companies and have naturally had to adapt myself to the particular business of each company. In general the tools used have been basic scientific principles as applied to the problems of the particular business, except of course, for innumerable special tricks acquired along the way.

I have often thought that graduates would thank their professors more for a few practical hints as how to get a job done than for a good deal of the intricacy taught them which is in the text books anyway. I remember a number of occasions when I found myself in the sure-I-know-what-to-do-with-the-figures-when-I-get-them-but-how-do-I-get-them position. A sort of intern year in shops, mines and mills would be a good thing for all engineers; too many fellows have too little idea of the intermediate stops between raw material and product and few of us have sufficient knowledge of what can be done with tools.

I would also favor teaching elementary geology as a cultural course and making it a prerequisite for all lines of study. We should all, as intelligent individuals, know a little bit about the planet we live on and how it got that way.

R. A. Wyman
Arvida, Que., Canada

See page 754 for news of the "MECHANIZATION AND METAL MINING EQUIPMENT SHOW" number, coming in August.

Authors in This Issue

S. A. Falconer

S. A. Falconer (P. 790) has been with the American Cyanamid Co. since 1927, as a mineral dressing engineer, special metallurgist, and sales service engineer. Prior to joining Cyanamid, Mr. Falconer was an engineer with the Brittania Mining & Smelting Co., and worked with the Granby Consolidated Mining Co. in Allenby, B.C. His research work on flotation has resulted in three technical papers which have been published by AIME. Mr. Falconer was born in Manitoba, attended Polytechnic H. S. in Los Angeles, and then took his B.A. Sc in mining engineering from the Univ. of British Columbia in 1924.

W. B. Stephenson

W. B. Stephenson (P. 801) will not see this issue for sometime, as he left for Sweden on July 1st to partake of some of the fishing and outdoor life he enjoys so much. When not busy writing technical papers, or serving as vice-chairman of the MBD's Unit Process of Materials Handling Committee, Mr. Stephenson is on the job as vice-president of the Allen-Sherman-Hoff Pump Co. in Philadelphia. Mr. Stephenson was born in Minneapolis, but he attended Germantown H.S. in Philadelphia, went to Penn State where he took his B.S. degree, and now lives in the city of brotherly love. He is, of course, an AIME member.

R. C. Specht

R. C. Specht (P. 779) is not only appearing in Mining Engineering this month, but also expects to appear in a southern magazine, where his article "Preservation of the Color and Shapes of Flowers" will be published. Prof. Specht is also an inventor, holding a patent on a method of making barium chloride. Now Prof. of chemical engineering at the Univ. of Florida, he also doubles as a research engineer at that school's engineering and industrial experiment station. His 26-year career has embraced work with three southern companies as chemical engineer, research chemist, and chief chemist. He attended high school in his birthplace, St. Albans, W. Va., and has taken B.S. Ch.E. and Ch.E. degrees at West Virginia University. He is a member of AIChE, ACS, ASEE, and the

(*Continued on P.* 752)

Amer. Assn of University Professors. Besides his interest in flowers, Prof. Specht enjoys the culinary arts.

C. E. Lesher (P. 805), president of the Disco Co. in Pittsburgh, was formerly president of the Pittsburgh Coal Co. He was editor of **Coal Age** from 1920-23. Mr. Lesher has been an AIME member for 30 years. Born in La Junta, Colo., he attended Union High School, and took his E. Met. degree from the Colorado School of Mines in 1908. From 1910 to 1919 he worked with the USGS. Mr. Lesher has presented one other TP before the Institute.

J. R. Lotz, who is chairman of Stone & Webster Engineering Corp. in New York, and also chairman of Overseas Consultants, Inc., presents an interesting account (P. 770) of the activities of eleven American consulting firms which have banded together to aid Iran in establishing a sound economy. Mr. Lotz is a native of Lockport, Illinois, attended High School in Joliet, and has a B.S. from the University of Illinois. He now lives in New York.

H. M. Ruth

H. Merton Ruth (P. 762), who was born in Edwardsville, Pa., and attended Penn State, has been a busy man in the coal industry. He has spent his whole career with the Glen Alden Coal Co., working up from colliery transitman through ventilation engineer and colliery superintendent to his present job as division superintendent in Wilkes Barre. In addition, he taught night mining classes at the Wilkes-Barre YMCA for 19 years, and headed the school for five years. He has also found time to write two technical booklets for the International Correspondence School. AIME member Ruth lives in West Nanticoke, Pa., and enjoys fishing for relaxation.

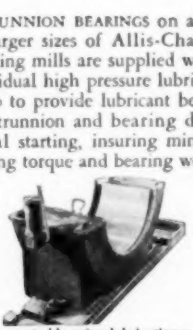
Overcome Problem of High Starting Torque

ALLIS-CHALMERS Grinding Mills

Check These Features!

- Trunnions built with maximum metal thickness at point of greatest stress.
- A gradual curvature from trunnion to head eliminates any localization of stress.
- Trunnion cast integral with heads for added strength.
- "One company" responsibility—buy your mill complete with motor, control and drive...proper feeder and liners . . . flexible coupling or magnetic clutch — all from Allis-Chalmers!

TRUNNION BEARINGS on all the larger sizes of Allis-Chalmers grinding mills are supplied with an individual high pressure lubricating pump to provide lubricant between mill trunnion and bearing during initial starting, insuring minimum starting torque and bearing wear.



Hand operated bearing lubricating pump.

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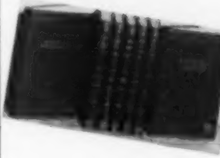

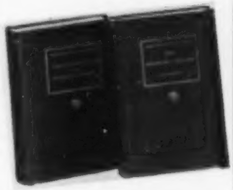

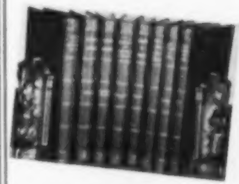

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* One effect of the British devaluation of the Pound Sterling, with its resultant lowering of the pay limit, was the addition of considerable tonnages of previously marginal ore in gold mining. Crown Mines, Ltd., reported that 1,245,000 tons of such ore had been added to available reserves. But for devaluation, a steady decline in ore reserves had been a feature of operations during the previous ten years, and would have continued.

* Loree Colliery of the Hudson Coal Co. is using a Humphrey spiral cleaning plant to meet requirements of the state in the matter of stream pollution. However, the process is producing a salable product.

* Noranda is considering plans for constructing a commercial sized unit designed to produce elemental sulphuric acid and sintered iron oxide from pyrite. Test plant results have indicated the No. 5 ore zone can be treated by the new process economically.

* A magnetic fluid clutch, and magnetic amplifiers for motor and generator control, have been developed under Navy contract by Vickers' Electric Division in St. Louis, Mo. This constitutes the first commercial production of the clutch recently developed by the Bureau of Standards.

* Fuel experts estimate coal production will run up to 500 million tons this year based on the expectation that business conditions will continue to be good. They also expect that in the future the use of coal will increase by 50 pct over today's level. These expectations are based on the fact that it provides the bulk of the heat, light, and power for making steel, for manufacturing, and for generating electricity as well as the development of the coal burning gas turbine and processes for making gas, gasoline, and oil from coal.

* Entombed miners may benefit from a two-way communication system which utilizes the earth's strata as a network for electric signals. The use of FM radio waves makes this possible. The invention includes a portable transmitter-receiver unit kept near the face, and a more powerful portable equipment of the same sort above ground. In use, two probes on wires from the apparatus are driven into the earth.

* The Union of South Africa has launched a uranium production project which government leaders think will help the West maintain world atomic supremacy. Experiments under way in the pilot plants are expected to lead to the establishment of a chain of processing factories along the Witwatersrand in which uranium will be reclaimed from gold tailing.

* Recent developments in mechanized mining at the Bureau of Mines oil-shale mine near Rifle, Colo., have lowered mining costs to 29¢ per ton of shale. The cost of producing crude shale oil from 30-gal-per-ton-shale, using the new mining and processing techniques, would be about $1.50 per barrel. This is 50¢ lower than any previously stated price.

* COMINCO is planning to open the old Bluebell lead-zinc mine near Nelson, B. C., on a 500-ton-per-day basis. The old workings will be pumped and a 970-ft incline sunk. A mill will be constructed at the property.

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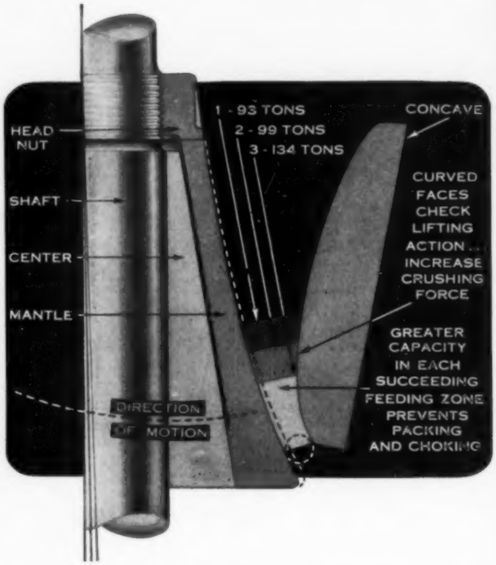

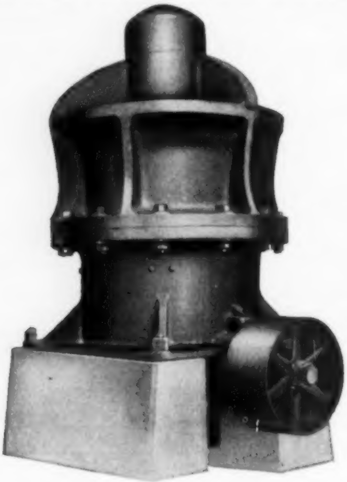

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Mining Engineering *Editorial*

Is Craftsman's Pride Vanishing?

"THE man most likely to succeed" has been elected by the graduating classes of our universities and by now these chosen individuals are launched on their respective careers. It is the method of measuring success in later years which is disturbing. Too much emphasis is placed on material possessions, title, and the frequency of appearance of one's name in the community newspaper in judging the "successful" person.

A friend of ours was recently lamenting the absence of professional pride in the engineers of this generation. He claimed that today's engineer was passing through the engineering phase of his career as quickly as possible to reach an administrative or executive position in which engineering skills are little used. Engineering was a stepping stone to something better. The something better was more money for exercising judgment in the management of labor and capital goods.

This absence of professional pride or, for that matter, the craftsman's pride in accomplishing skilled work is a real danger, and we think it is related to the criteria by which personal success is recognized. How often have you remarked to yourself that the shoemaker is a far cry from the skilled craftsman who repaired shoes in your boyhood town, or that the miner of today "ain't what he used to be?" People are prouder of their automobiles, homes, or the clubs that they belong to than in the skills which provide the luxuries through the dollars that are earned. As long as the method of gaging success is by the standard of living of the individual concerned, engineering skills are likely to suffer unless the engineer's standard of living is raised. This, however, will not cure the evil alone, because something is wrong basically with the training, the upbringing, or possibly the entire national environment, when highly skilled people do not have that burning desire to be "the best danged mill man" or the best at whatever the profession happens to be.

A possible objection to being the best at one's job was voiced by our old revered college dean. He cautioned his students that it was possible to get up a blind alley in a professional career if one became too valuable in one's present position. This obstacle is easily overcome if we follow the example of the good supervisor who takes pains in bringing along a series of capable replacements so that he may be promoted without detriment to the organization when the time comes.

A renaissance in professional pride is needed. Among ourselves we must esteem engineering accomplishments. We must gage the "successful man" by what he does rather than by the brand of liquor he serves. It would not be amiss if company policy permitted some material recognition of engineering achievement because we don't agree that engineers, like artists, must suffer in order to create.

It's Everyone's Business

PUBLIC hearings began before the Committee for Reciprocity Information on May 24, 1950, for the purpose of unearthing data and opinion that will be helpful in the forthcoming reciprocal tariff and other trade-barrier negotiations at Torquay, England, on September 28th of this year. The conference this fall will constitute the "third round" of tariff negotiations under the General Agreement on Tariffs and Trade concluded at Geneva in 1947. The United States plans to negotiate with 17 other countries on possible tariff modifications on various articles all the way from baby carriages and bottle caps to lead and zinc-bearing ores.

On May 31, June 1 and June 2, spokesmen appeared before the Committee for Reciprocity Information on behalf of the domestic lead and zinc mining industries. Producers of these metals protested the inclusion of paragraphs 391 (lead-bearing ores, dust and mattes), 392 (lead bullion, lead in pigs and bars, and scrap lead), 393 (zinc-bearing ores of all kinds), and 394 (zinc in blocks, pigs or slabs, and zinc dust) of the Tariff Act of 1930, as amended in the list of articles to be considered for possible tariff concessions at Torquay.

It was pointed out that although operating costs have more than doubled since 1939 tariffs on these metals were actually higher in that year than at present. This, coupled with the detrimental effects of the recent series of devaluations, has sounded the death knell for a substantial number of domestic lead and zinc mines—a most undesirable development in the face of the ominous international situation, according to these spokesmen. It was urged that higher rather than lower tariff rates are needed on these metals. The opinion was expressed that it was inconsistent to foster a high living standard in our western areas and then, once it is attained, to undermine that condition by minimizing the protection that was partly responsible for it. The main theme of some arguments implied that although every effort should be made to close the "dollar gap" abroad, serious consideration must be given the methods employed lest our national security position be jeopardized in the process.

The House Committee on Foreign Affairs completed hearings on H. J. Res. 236, to provide for United States membership and participation in the International Trade Organization. Hearings began on April 19th and ran for over five weeks. Many witnesses from industry and government presented voluminous testimony, which will not be available for public distribution for several weeks. However, it is no secret that the most controversial provisions of the Draft Charter of the ITO are: (1) Article 17 (Chapter IV on Commercial Policy) which would obligate members to negotiate for the reduction of tariffs and the elimination of trade preferences; (2) Article 20 which would prohibit the use of quantitative restrictions for protective purposes; (3) Article 16 which promulgates rules to implement the principle of non-discrimination in international trade; and (4) provisions permitting the use of protective measures for promoting economic development, particularly in backward areas, even though such provisions are inconsistent with those of the three articles cited above.

United States membership in the International Trade Organization is essential to the successful operation of that body in view of this country's position as the economic giant in the present international trade pattern. Many countries are reluctant to take any action toward the ratification of the charter until it is known what course America will pursue. However desirable or undesirable the ideal of free multilateral trade may be it is unlikely that this Government's participation in the ITO will materialize soon. Advices in Washington indicate that H. J. Res. 236 will not be enacted during the present session of Congress.

The legislative pattern designed to secure Congressional approval of the ITO is similar to that of the St. Lawrence Seaway project. The Seaway project was pending in treaty form for several years before the Foreign Relations Committee of the Senate and when the Administration decided to incorporate this project into bill form it was found that, while it passed the House promptly, the Senate decided to pigeonhole it because of the obvious intent to circumvent the constitutional prerogative of the Senate to advise and consent to the ratification of treaties. The ITO bill may be slated for a similar fate.

It is deemed essential by western Senators and Congressmen that the present session of Congress enact some form of mining legislation before its adjournment, now set for July 31st. These legislators from prominent ore-producing states do not desire to return to their home areas in the fall empty-handed. Aside from that, it is entirely superfluous to reiterate the necessity for maintaining a healthy domestic mining industry as a bulwark against a sharp rise in the temperature of the "cold war". Now that S. 2105 has failed a new bill is taking shape in the Senate Interior and Insular Affairs Committee. It is similar in language to H. R. 8221 (to encourage the conservation and development of the mineral resources of the United States) reported by the House Public Lands Committee on May 3, 1950, but so far has failed to receive approval of the House Committee on Rules.

There are some qualified observers in high circles in Washington as well as in the mining industry who favor a tax incentive program to stimulate investment in mining enterprises, as opposed to a conservation and exploration program. The Bureau of Mines and the Treasury Department have undertaken a joint study to determine the need for modification of the tax laws as they apply to mining. The study is scheduled for completion before the end of the year, and appears to be supplementary to the investigation initiated by the National Minerals Advisory Council which culminated in the submittal of recommendations to the Secretary of the Interior in December 1949.

The "cold war" is largely responsible for the increased demand for metals. Stock-pile purchases and heavy industrial demand due to military needs distort markets and disrupt normal price trends. Such activity has an unhealthy influence on metal production, luring some producers into a state of dependency on the continuation of this condition. When stock-pile objectives are met sometime in the future purchases must then come to a halt unless international "fireworks" are touched off. It can only be hoped that technological improvements and further mechanization of mines coupled with the stimulus of a rising population will offset the anticipated drop in industrial demand and cessation of stock-pile purchases when the international crisis abates.

Anthracite

Turns to

by H. Merton Ruth

Mr. Ruth is division superintendent, Glen Alden Coal Co., Wilkes-Barre, Pa., and an AIME member. This paper was presented at the Pennsylvania Anthracite Section Meeting AIME, April 28.

THE northern anthracite fields, although facing the same economic problems as the southern fields, are confronted with the additional problem of fast dwindling reserves of anthracite which can be conventionally and economically won.

The mining of coal which remains in thin beds and the recovery of pillars from areas heretofore considered unrecoverable, either by reason of cost or surface restriction, pose problems of increasing importance to the economic life of the northern field operations. Successful approaches have been made to this problem and other work is being performed that holds promise.

There exists in the northern anthracite field millions of tons of solid coal, the recovery of which has not been too successful due to the following inherent operating faults: inability to concentrate producing areas, the great quantities of rock to be cut and handled, lack of consideration of proper sequence and speed of second mining, and the continued use of the mine car as the basis of payment.

A mining system that has successfully solved these major problems has been in operation in the Scranton area since 1944. Over 1½ million tons have been produced from veins varying from 3 to 4½ ft thick by this method, which is known as the **multiple panel-triangular system—conveyor mining.**

The main features of the plan are large number of producing faces in small area, elimination of the mine car as a measuring stick of face performance, providing a selection in choice of equipment, elimination of disadvantages of long waiting periods between first and second mining, use of 440 ac power giving advantages of more constant voltage and fewer power interruptions.

Multiple Panel—Triangular System

Fig. 1 shows a general plan for a given area illustrating the development roads 1, 2 and 3 all in progress. Road 1 is the main belt gangway; roads 2 and 3 are chain conveyor headings. When road 1 has advanced beyond the first transfer

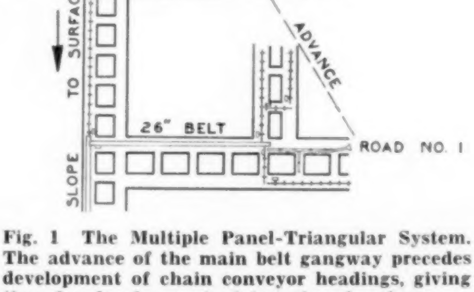


Fig. 1 The Multiple Panel-Triangular System. The advance of the main belt gangway precedes development of chain conveyor headings, giving time for development of transfer chambers.

Mechanization *and* Pillar Recovery

chamber, the 26-in. belt conveyor is installed to the transfer point. Roads 1, 2 and 3 must then have advanced to the positions shown, and the angle formed by their respective positions maintained to the panel limit; in this way the time needed to drive transfer chambers is provided.

The vein in the illustration is 4½ ft high with 3½ ft of coal. All development roads are driven 25 ft wide, chambers 25 ft wide on 50-ft centers leaving a 25-ft pillar, which are broken through by cross-cuts driven 12 ft wide.

A minimum height of 4½ ft is maintained in the belt gangway. When bottom rock is cut to provide the necessary height on the high side of the gangway, one of the following three plans is followed: 1—Coal and rock are blasted simultaneously and loaded by duckbill. The rock is picked from the coal at a belt picking station inside or outside the mine, depending upon local conditions. 2—After coal has been cut and removed, an inverted action bell crank is placed in the duckbill pan line at points of cross-cut and the rock is discharged into cross-cuts. 3—After the coal has been cut and removed, the bottom rock is cut and a face maintained 75 ft back of the coal face. This rock is hand gobbed in the road between the belt and pan line.

Fig. 2 illustrates the triangular system when at its productive peak of first mining and robbing. This triangle will move along the line of advance 3000 to 5000 ft, depending upon the available area.

Road 1 is still advancing with its airway; two chambers are advancing toward Road 2. The outside chamber will be used as a transfer chamber, and is 300 ft inside the last breakthrough from road 1 to 2.

Roads 2 and 3 each have six solid places and four pillar places. Uniformity in force and production is maintained when needed by adding a 7½-hp face conveyor in chambers when driving cross-cuts.

The location of units and flow of the coal at this point is indicated in Fig. 2. Three men make up each face crew. Using a year's record, the average daily production from this particular area 1000 x 800 ft with 24 producing faces has been 859 tons for a single producing shift. Supplies are taken in and equipment moved on the second shift.

A Pennsylvania Anthracite Section Contribution

Elimination of Mine Cars as Criteria of Face Performance

Generally, mechanical loading and conveying installations in the Scranton area have been handicapped because the rate sheets for hand mining are based upon a rate per car. In many installations of shakers and conveyors in low coal a saving is effected only because less top or bottom rock is lifted. The cars of coal per man invariably show little improvement over the old system of bringing the mine car to the face.

By an agreement with the United Mine Workers in the late 1930's the mine car rates were abolished and new rates based upon an improved face performance were established, resulting in greatly increased production per man as compared with the former methods using mine cars.

It was found that many of the remaining solid low coal areas, with bottom irregularities and rapidly changing pitch, could not be undercut efficiently. With this in mind the plan described was developed. The plan was carried out without the use of mine cars and during 4½ years operating under the plan a 65 pct increase in production per face-man has resulted.

When the pitch is flat and up to 7°, chain conveyors and shaking conveyors have been used without any particular change in face performance. When the pitch is from 7 to 15°, chain conveyors have been used in rooms. When the pitch is above 15°, short curved chute sections, locally known as dead pans, are used. Equipment used when removing pillar coal follows the same pattern, except when the pitch is under 15° and excellent roof conditions exist, then double drum hoists and scoop installations greatly improve face performance. However, chain conveyors, in spite of lower performance, are preferred because delivery of supplies to the working face can be guaranteed.

Areas selected for this type of mining must necessarily be limited to those where immediate and complete removal of the coal is possible.

Reinstallation of mechanical equipment in areas that have stood over long periods is pro-

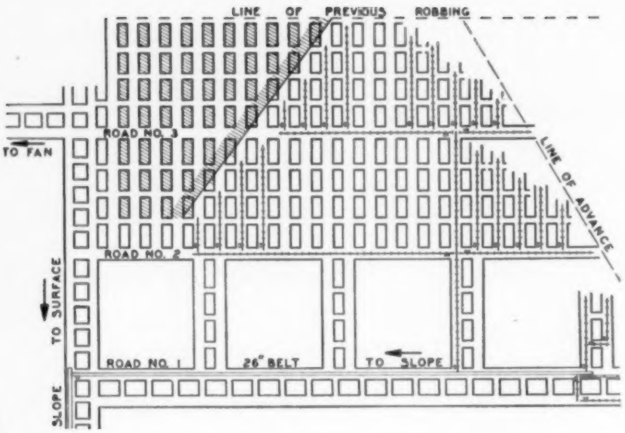


Fig. 2 The triangular system shown at its peak of first mining and robbing. Average daily production for this area (1000x800 ft), with 24 producing faces, has been 859 tons for a single shift.

hibitive from a cost standpoint. The plan presented permits first and second mining on roads 2 and 3 as the panels advance, and a similar procedure on road 1 when retreating from the panel limit. When the plan proceeds in proper sequence, conveying equipment is installed as rooms advance, and removed during the extraction of the pillars.

The use of 440 ac power has been found highly advantageous in this type of concentrated mechanical mining. As the panel advances approximately 1000 ft a bank of capacitors are moved to the load center. In this way improved voltage conditions are maintained resulting in lowered power cost, lowered maintenance of equipment and consequently less production loss through power and equipment failure.

Interlocking controls are provided on all conveyors, so that if any conveyor stops for any reason, all conveyors from that point to the face will stop automatically. Each conveyor must then be started individually to resume operation, thus insuring against the possible hazard of a conveyor being set in motion at some remote point while men are working on the conveyors.

Hydraulic Flushing for Pillar Removal

Many collieries in the northern field must rely upon pillar recovery to maintain their economic life. A majority of the pillars remaining in this area may only be removed provided that surface subsidence be avoided or kept to an acceptable minimum.

There are two recognized methods of controlling surface subsidence, namely, hydraulic flushing with comparatively fine grained material and manual and mechanical stowage of coarse material. Backfilling fine grained material mixed with water in mined areas is not a new idea since there is a record of it having been used in 1880 both in this country and in Germany. One colliery in Upper Silesia replaces 80 to 90 pct of its coal production with back fill.

Three case histories will be presented in this paper, all of them of similar nature, only varying in the methods used in accomplishing the same results. All three cases are located in the Wilkes-Barre-Plymouth areas under the Susquehanna River basin. Those cases have been particularly selected since they are presently active and presumed to be profitable.

Pillar Recovery

The first case is that of the successful recovery of pillars under river wash by packing with mine rock. The seam is approximately 9 ft thick with a good slate roof. Chambers were mined on 60-ft centers, 24 ft wide, leaving 36-ft pillars. The chambers had been previously hydraulically flushed with breaker refuse as shown on Fig. 3. The seam pitches about 10 or 12°. There is no minable coal overlying the area and there is about 350 ft of overburden with 75 or 100 ft of sand and gravel on top of the rock strata.

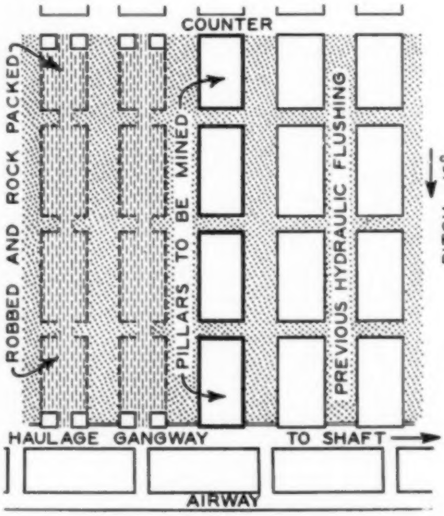


Fig. 3 At left, 36-ft pillars have been robbed and rock packed, and hydraulic flushing with breaker refuse has been completed preparatory to mining the remaining pillars.

Mining is advanced by splits from 10 to 15 ft wide as shown on Fig. 4, stages 1 and 2. Shaker chutes convey the coal to the gangway where it is loaded into mine cars. Rows of two props on 6-ft centers are set advancing and additional props are placed where needed during the retreat.

Mining is done by 1 machine miner and 4 machine laborers working on each of two shifts. It requires about 35 working days to completely remove the coal from pillars along one chamber.

Mine rock is used to backfill the robbed area and filling is done from the upper road. Simultaneously with the advance of the splitting of the pillar preparations are made off the upper road in that pillar for a rock dump, suitable for handling one car at a time, stage 2. As soon as the split mining is completed, a shaker chute is installed from the rock dump down the place on a line with the retreating pillar mining, stage 3. Rock is dumped and hand packed along the voids created by the retreating miners. Excessive weight soon becomes evident and it has been found expedient to erect 3 or 4 cogs in each line of pillars, these take the weight in a satisfactory manner and complete rock packing is done from and including the lower gangway to the upper gangway without any further difficulty from broken roof, as shown on stage 4. It requires the services of 3 men working on each of two shifts to perform this rock packing procedure in a satisfactory manner and the job is completed in from 20 to 25 working days.

Hydraulic Flushing with Fine Grained Material

The second case to be discussed is that of pillar recovery under surface protected areas by hydraulic flushing with very fine grained material.

The pillar area under discussion comprises approximately 3½ acres. The seam is approximately 7 ft thick that had been first mined to 72 pct of the original vein content and the remaining opening flushed with silt. The nature of the roof is hard sandstone and the pitch of the measures is about 6°. The vein lies 175 to 220 ft below the surface, the overlying strata consisting of 105 to 135 ft of clay, sand and gravel and about 50 to 80 ft of sandstone.

The weight of the pillars after the first mining was completed was 55 tons per sq ft. The coal in this particular vein was tested for its compressive strength and was found to withstand a weight of 139 tons per sq ft, developing a factor of safety of 2.5.

The method of mining is to remove two rows of pillars at a time. The reason that two rows must be removed is to properly ventilate the faces of the advancing places.

In the initial stage a portion of the battery is knocked out and a skip is started on the outside rib. Crosscuts are driven as indicated by removing about 6 ft of inside rib on the pillar and digging a hole through the silt in the old chamber just large enough for a man to work in. As the pillars are about 16 ft wide, a minimum skip of 6 ft is taken on the advance. Props are placed along the silted side. These hold most of the silt in place and the little that does fall is used as ballast for the track.

As soon as two rows of pillars are removed, silting operations are promptly started. A 6-in. pipe from the upper road is placed in the opening formerly occupied by the pillars and flushing operations are begun. Due to the consistency of material used, which is taken from a silt tank, it flows directly down the pitch and packs against the stump pillar left to protect the gangway. The process of backfilling the entire opening takes about five days.

The recovery of the pillars to date has been excellent; practically all of the coal being removed. Coal, which is blown into the gob and left as small stumps to create a break in the roof area which has not been silted, is recovered.

In order to measure the resulting subsidence on the surface, iron pins about 2 ft long were driven into the surface and basic elevations were run over these pins. Up to this time surveys indicate that there has been no settlement. However, this is probably due to the fact that the pillar removal operations have not advanced far enough to have any effect on the overlying strata. After all the pillars in the entire panel have been

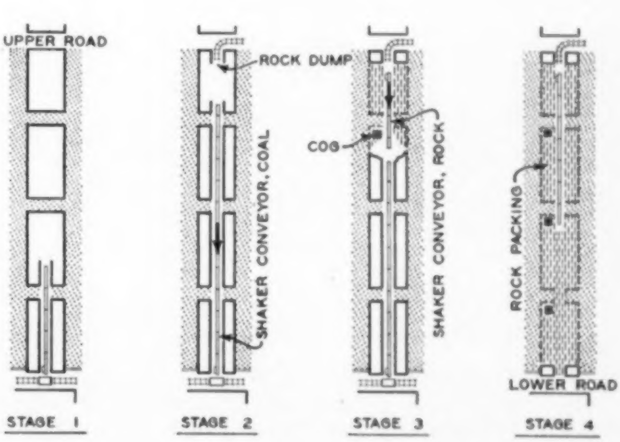


Fig. 4 Pillars are mined by splits from 10 to 15 ft wide, and the coal removed on shaker chutes. The robbed areas are backfilled with mine rock, and filling is done from the upper road.

removed, a survey will again be made over these iron pins to determine the extent of the settlement.

Hydraulic Flushing with Pulverized Breaker Refuse

The third and last case to be discussed is a successful recovery of pillars under river wash, by hydraulic flushing, with pulverized breaker refuse.

The vein being recovered is from 10½ to 11½ ft thick, with a 4 to 10 ft fireclay top. The vein varies from flat to a 7° dip, and flushing is facilitated in places having the heavier dip. Eighteen in. of top coal was left in place to support the fireclay and later removed in chamber mining but not recovered in the pillar removal. Chambers were mined on 60-ft centers, 24 ft wide, leaving 36-ft pillars. The chambers had been previously flushed with pulverized breaker refuse.

Three veins overlie the area. First mining has been completed in two of the veins while one vein is virgin. The total thickness of overburden is 400 ft, 100 ft of which is sand and gravel.

Mining is advanced by splits driven 10 to 15 ft wide in two adjacent pillars, and is to the dip. During the driving of the splits, props are placed on 6-ft centers in rows of 4. This brings one prop on each rib and makes additional propping unnecessary during the retreat. Splits vary from 200 to 350 ft in length depending on the distance from the car road to a fault. Some movement of the strata has been observed at the beginning of the split when the extreme length has been reached. This condition has not been serious so far. After the split has advanced to the fault, the shells of the pillars are removed while retreating.

One machine miner and three machine laborers work in each place on each of two shifts. The coal is transported by chain conveyors to mine cars on the car road. A normal pair of splits 250 ft in length are driven and the pillars removed in 40 working days. Backfilling requires 4 days.

Since retreat is up the pitch, flushing preparations are made while pillars are still being recovered. This has been found advantageous, so that flushing can be done immediately to hold the roof in the event of any protracted period of idleness.

Wooden flush troughs, measuring 8 x 10 in., and covered with 3-in. slats spaced 3/16 in. apart, are laid the entire length of the split. Clear water drains off through the trough under the settled material and passes to the main sump. To further facilitate drainage, wood stacks are erected vertically over the main trough to the roof every 50 ft where the dip is 6 or 7° and about every 20 ft where the seam is flat. This combination provides adequate drainage and 5 min after flushing operations have stopped the flushed material is firm to the tread. The upper edge of the flushing is contained by a battery erected on the low side of the car road. Owing to the proper run-off, little pressure is exerted on the battery.

Duckbill Mechanical Loading

The scraper loader, a direct development of the anthracite industry, along with chain, belt and shaker type conveyors, provided the first means of transporting the coal from the working face to mine cars on the gangway on flat pitches without the costly process of cutting bottom rock for car height.

Of these mechanical developments, the shaker conveyor has emerged as an outstanding device for conveying anthracite. Its flexibility adapts it to almost any condition encountered in room and pillar and longwall mining. The usefulness of the shaker conveyor was extended by the development and application of an auxiliary device called a duckbill, which loaded the conveyor mechanically.

The duckbill was first introduced into the anthracite field by the Hudson Coal Co. in 1926, for combination with a shaker conveyor imported from England.

This device consists essentially of two reinforced troughs, supported independently one over the other, and held together by a feeding mechanism. The bottom trough, known as the feeder trough, is bolted rigidly to a swivel and the swivel is connected to the conveyor trough line. The upper, or shovel trough, is the movable part of the duckbill. The shovel trough, which has a flattened head, is forced ahead of the feeder trough by clamping the two troughs together during the impulse of the forward motion of the shaker drive. To retract the shovel trough clamping is done on the retreat motion. The crude ratchet feed, which provided the means of advancing and retracting, was found to be too cumbersome and heavy for practical use.

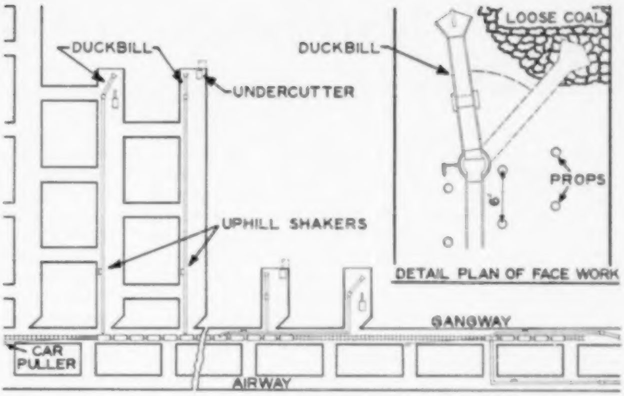
Further experiments were made in 1930 with the type LA duckbills made by the Goodman Mfg. Co. These experiments were discontinued after a short time, because the duckbills were too heavy for the troughing and drives then available. Actual success was not obtained until 1933, when with redesigned troughing and drives, a low coal duckbill, Goodman type LOA, was introduced. In 1935 the same manufacturer introduced an improved unit, type LOB, in which an arrangement of independent support afforded more positive control.

A semiautomatic duckbill was put in service in 1939, followed in 1946 by the model currently being used. Through action of a spring connection, the motion of the feeder mechanism was synchronized to function automatically with the strokes of the shaker drive unit.

A typical application of duckbill loading at the Olyphant-Eddy Creek operation of the Hudson Coal Co. will be discussed.

Duckbill loading into shaker conveyors has been successfully conducted at different times in small areas of practically all the coal veins. In Dunmore No. 4, the bottom vein, duckbills have been used almost exclusively in development and chamber work for a number of years and are in service at the present time on ten shaker conveyors. This vein varies from 54 to 78 in. thick, and is overlain by a 6-in. band of black slate which must be taken down with the coal for safety. Except for small bands of boney near the bottom, the bed is free of impurities. The main roof above the drawslate consists of stiff shales or strong sandslate which usually require props stood on 6-ft centers. The bottom is rela-

Fig. 5 Augmenting the work of the shaker conveyor, the duckbill serves to load conveyors mechanically. Used in combination with an undercutter, it is used to advance chambers 70 ft before the shaker unit and conveyor line are dismantled and moved up.



tively smooth sandstone on which the loading head can easily be moved across the chamber.

The plan of development as laid out provides for a gangway and its accompanying airway, each 12 ft wide, driven on 42-ft centers. Bottom rock is cut where necessary in the gangway to provide a minimum of 5½ ft over the rail. Crosscuts are driven every 60 ft.

Rooms 24 ft wide on 74-ft centers are driven 300 ft, usually up the pitch. Crosscuts 12 ft wide are driven every 60 ft, and reserve pillars 124 ft wide are maintained every ten chambers.

Two shaker conveyors with duckbills attached are used in gangway and airway development work, one in each entry, using a common loading place located on the gangway. This is made possible by inserting a 90° angle trough to turn the pan line through a crosscut connecting the airway with the gangway, as shown in Fig. 5.

To obtain full advantage of loading by the duckbill throughout the entire length of a chamber, the shaker drive unit is first installed in the gangway. The pan line is laid along the one side of the gangway and turned by a 90° angle trough at the chamber opening. The duckbill is used for advancing the chamber a distance of 70 ft and then the shaker unit and conveyor line are dismantled and reassembled in the chamber.

The coal is first undercut to a depth of 7, or in some cases, 8 ft, by combination longwall and shortwall machines which cut a 6-in. kerf with standard replaceable bits. Dust concentrations are kept well within the standards set for such work by cutter bar spraying.

Seven holes are drilled to the depth of the undercut with wet type compressed air drills. Four sticks of permissible explosive are used in each of the top holes and three in each of the bottom holes, all tamped with two bags of stemming per hole. The center holes are detonated with electric blasting caps and the rib holes with delay electric igniters. This method of face preparation breaks down the coal with minimum scattering, which is desirable for duckbill loading.

A chamber crew consists of one chargeman, one machine runner and helper, one duckbill operator, two laborers, and one carman. They alternate between two chambers cutting, drilling and blasting in one while loading in the other. The chargeman supervises the work in both places and helps where needed. The carman tops the cars on the gangway, handling them in trips of ten with a remote control tugger hoist.

In the entry development work a smaller crew is used, consisting of the chargeman, one machine runner, two laborers and one carman. The cycle of work is similar to chamber mining, two men doing the preparatory work in the gangway while the other three are loading in the gangway.

Production in chamber mining amounts to 110 tons for the 7-man crew, or 15.7 tons per manshift. This production is reduced in entry development because of the narrow openings.

The foregoing considered the use of duckbills on conventional pitches. Successful results have been obtained in the Nanticoke area in the use of duckbills on pitches up to 25°. The difficulties encountered in operating on this heavier pitch were the excessive speed of the coal in the shaker pans, and the tendency for the pans to buckle. To offset the speed of the coal retarders were installed in the chutes. These retarders were simply short pieces of weighted rail suspended in the troughs. To prevent buckling of the shaker pans it was necessary to insert a guide frame every 20 ft or second pan. These guide frames were then propped or jacked down.

When the breast had advanced 150 ft, it was found to be an advantage to move the drive unit up the pitch about 100 ft, thereby balancing the load on the drive unit.

These foregoing examples define unmistakably the trend of northern field mining in the direction of a wider use as well as a more judicious utilization of mechanical conveying equipment and a greater emphasis on pillar recovery.

Acknowledgments

I wish to express my thanks to my co-authors, Messrs. **John Humphrey**, mining engineer, Lehigh Valley Coal Co.; **Earl Lamb**, general manager, Moffat Coal Co.; **Edward Powell**, mining engineer, Susquehanna Collieries Div., M. A. Hanna Co.; **Wesley Stonebraker**, superintendent, Olyphant Colliery, Hudson Coal Co.; and **F. E. Kudlich**, mining engineer, Glen Alden Coal Co.

Northwest IMD Reports

Nonmetallics group sees greater expansion. New Westvaco plant hailed.

INTO their great Pacific Northwest counting house went the members of the Industrial Minerals Division recently, to count their blessings amidst the scenic grandeur and mineral wealth of the State of Washington. From their vantage point in Seattle, those who attended the IMD's fourth Pacific Northwest meeting turned their sights to the South and Southeast, scanned Montana, Idaho, Oregon and Utah, and predicted a very healthy economic future for their region.

The praises of Idaho's booming phosphate industry were sung by Earl W. Murphy, secretary of that State's Chamber of Commerce. He said the establishment of Fort Hall, on the banks of the Snake River near Pocatello, first turned the eyes of the world toward what is now the center of the greatest known deposits of phosphate rock—the section adjacent to the common corners of Idaho, Wyoming and Utah. With the founding of Fort Hall, Mr. Murphy said, historians will also rank the construction of the first electric furnaces for the production of elemental phosphorous as equally significant in the commercial history of the West. Those furnaces were installed only last year by the Westvaco Chemical Div. of the Food Machinery & Chemical Corp. at Pocatello, at a cost of $8 million.

Turning to review the history of the western phosphate industry, Mr. Murphy noted the early discoveries of phosphate rock in Cache and Rich counties, Utah, in 1889, the beginnings of Anaconda's mine at Conda, Utah, and the establishment of Anaconda's pilot plant for the manufacture of phosphate fertilizer at Anaconda, Mont., back in 1919-20. All western phosphate mining was underground until 1945, when the San Francisco Chemical Co. entered the field with its Waterloo mine near Montpelier, Idaho, and produced some 650,000 tons of 31.5 pct P_2O_5 within two years. Anaconda's production to date has exceeded 2,000,000 tons, with a daily capacity of about 600 wet tons, Mr. Murphy said. In 1944 the Simplot Fertilizer Co. became a producer, and two years later, after extensive diamond drilling, opened its open-pit mine at Fort Hall. Now, between the Simplot operation and the Gates Brothers plant at Wendell, Idaho, 52,000 tons of P_2O_5 plant food are produced annually, which amount is more than enough to supply the needs of the eight western states of Montana, Idaho, Wyoming, Utah, Nevada, Oregon, Colorado, and Washington.

The speaker went on to cite the salt supplies around Salt Lake, the soda ash deposits of the Green River, and abundant supplies of coal, oil, natural gas, and hydro-electric power as the advance guard of "tremendous expansion of a great and diversified chemical industry" in the west. The supporters of government intervention in the phosphate fertilizer business, Mr. Murphy claimed, are singing a roundelay containing numerous errors. Their contention is based on the reasoning that cheap government electric power can lower the cost of fertilizer production, but their glaring fantasy is in believing that cheap electric power will do the trick—when in reality, according to Mr. Murphy, the acid process is cheaper. The electric furnace method used by Westvaco is powered by the hydro plants of the Idaho Power Co., and there is a lot more power available for any super-phosphate producers who want to enter that business in Idaho, he said.

The New Westvaco Plant

Some of the strange and wonderful things ground out by the mills of the gods and the minds of men were brought to light by J. G. Miller of the Westvaco Chemical Div., Food Machinery and Chemical Corp. Back in 1932 his firm discovered a new type of sodium phosphate, called tetrasodium pyrophosphate (T.S.P.P.)—but no one knew just what it was best suited for. At the same time, owners of cafeterias were wringing their hands, in search of something that would render hard water soft and prevent the accumulation of lime deposits on their oft-used dishes. Ordinary soaps, as the advertisers say, would not do the job. In fact ordinary soaps and alkalis then used were causing the lime deposits to form. T.S.P.P. came to the rescue and began suppressing the calcium and magnesium ions in hard water, while at the same time keeping it clear and free from precipitates. In the midst of the worldwide depression, the company had literally stumbled on a gold mine. Later on, T.S.P.P. brought a big brother along, sodium tripolyphosphate, another product of the inventive minds at the Food Machinery & Chemical Corp., and which is now incorporated in some of the most popular household washing compounds on the consumer's market. It is produced at the rate of millions of pounds a year, said Mr. Miller, and accounts for consumption of a high percentage of all the elemental phosphorus manufac-

At the meeting were: G. M. Valentine, W. A. G. Bennett, C. P. Purdy, Jr., W. L. Stanton, M. T. Hunting, and S. L. Glover. The beards are a tribute to the centennial anniversary of Olympia, Washington's state capital.

tured at the Westvaco plant in Pocatello. In Mr. Miller's words, "a chemical element that was once worth its weight in gold is now so cheap that its derivatives can be incorporated into a low-priced household washing compound."

A bit of history and an explanation of the chemical and metallurgical aspects of Westvaco's manufacturing methods were also provided by Mr. Miller. Noting that elemental phosphorus was discovered 300 years ago by an alchemist seeking a Philosopher's Stone which would turn base metals into gold, he commented that "it was common knowledge among alchemists that good yellow metal could be made to grow in a mine, like potatoes in a field." The alchemist Brandt set the pattern for phosphate production when he took "50 to 60 pails of properly aged urine, boiled it down to a pasty consistency, mixed it with silica sand, placed it in a retort with charcoal, and fired it for several days." His metallurgy has not been improved upon, even after three centuries, said Mr. Miller. The new electric furnaces at Westvaco are producing both ordinary phosphates, such as monosodium phosphate, disodium phosphate and trisodium phosphate; and molecularly dehydrated phosphates such as those mentioned above, which are widely used to soften hard water and treat boiler water.

The Silica Business is Hard Pressed

The phosphate industry, as represented by Westvaco, had glad tidings and interesting tales for those attending the IMD conference, but the Oregon silica industry, as represented by F. I. Bristol, president of the Bristol Silica Co. at Rogue River, took on the appearance of a Sisyphus, condemned to roll an obstinate rock up a steep hill. This is not to say, however, that Mr. Bristol brought a rain cloud to the gathering. Rather, his attitude was summed up in a very few words: "Give us another ten years of problems and we should have them licked."

The problems began, he said, when low-cost power from Bonneville sent the electrometallurgical industry to the West in search of high-grade, low-cost silica. "It was definitely a disappointment to find that transportation costs would exceed cost of material," Mr. Bristol noted, and we may assume that this was somewhat of an understatement. However, the industry arrived, it is in production, but "it has been a hectic experience for most of the parties."

Other disappointments included the fact that the larger deposits are over 300 miles from main points of consumption, that they are not located near railroads or paved highways, and, in addition to all this, the experience of the present operators has been with limestone and other soft rocks. Silica, Mr. Bristol said, works its way doggedly into ball bearings, causes a very high turnover in crushing plates, and also has marketing problems all its own, as consumers are extremely careful about types and amounts of impurities in the finished product.

Strangely enough, the western silica producers are not in an advantageous competitive position as regards the eastern producers. The obvious advantage in freight rates when selling to western markets is canceled completely by two factors: the necessary truck haulage from areas not located near railroads, plus the fact that western producers have surplus quartz in some size ranges which must be processed, while their eastern competitors have quartz that has been brought to size by nature.

"It takes a long, long time to pick up each new customer," said Mr. Bristol, and then he elaborated with the unfortunate story of the Silica Products Co. at Eugene, Ore. This firm was producing a "very remarkable" steel molding sand which had long life and had been lauded by various foundries. The plant was in operation during the war, and thus had certain transportation advantages. However, a stiff sales resistance was encountered, which Mr. Bristol attributed to the fact that molders hated to change when everything was running at top capacity. The plant at Eugene finally had to close its doors, and the best steel molding sand on the Pacific coast is, like Clementine, "lost and gone forever." Over its remains, a home-building site is flourishing. The Wylie Hemphill plant at Dennison, Ore., supports the silica business by producing limestone and granite poultry grit. Mr. Bristol's company is also making "teeth for chickens."

Identification of Nonmetallics

Professor James I. Mueller of the department of ceramic engineering at the Univ. of Washington was on hand to review the latest techniques in determining the physical properties of nonmetallics. Differential thermal analysis is, he said, becoming more common. This method correlates the intensity and position of exothermic and endothermic reactions with respect to temperature, and simplifies the determination of decomposition of carbonates and sulphides, as well as the temperatures at which phase changes take place within minerals as they are heated or cooled. He also accented the use of X-ray diffraction techniques, which can be used for both qualitative and quantitative determinations.

Infrared radiation methods have also come into their own, according to Professor Mueller. They utilize the fact that complex ions have characteristic vibrational frequency within the range of the infrared spectrum. Infrared radiation is passed through a suspension of the mineral and falls on a photocell connected to a galvanometer, which indicates peaks due to the absorption or transmission of the radiation, depending on the material in suspension.

Next Meeting in Oregon

This totting up of the nonmetallic wealth of the Northwest was, on the whole, of great value—statistically, technically, and perhaps even psychologically. Representatives from the Columbia and Oregon Sections, from the Vancouver Branch of the CIM, and from nearby British Columbia were all well entertained by the North Pacific Section, and certainly all of them went away with a better knowledge of their region and with an assortment of high hopes for its future. The Oregon Section expects to sponsor the next gathering of the IMD group. Meanwhile, the timbered slopes, the wide plateaus, and the rugged mountains of the Pacific Northwest wait upon the decisions of the men of vision who are, perhaps, not unlike their famed predecessor Paul Bunyan.

IRAN

A team of American experts is tackling a whole nation's problems, under the banner of a seven-year plan evolved by the Iranians themselves.

by John R. Lotz

Mr. Lotz is chairman of the board, Overseas Consultants, Inc., New York City. This paper was presented before the Mineral Economics Division, AIME, at the 1950 Annual Meeting.

DEVELOPMENTS in Iran currently arousing interest in a considerable portion of the world, particularly on the part of that country's immediate neighbor on the North and in our own country, are inseparably related to and largely dependent upon the government's attempts to strengthen its economy and improve the standard of living of its people. These efforts are encompassed by provisions of the Seven-Year Development Plan recently enacted and now in the process of implementation. It is a fine example of what one financially sound but extremely backward and poorly equipped country has undertaken to do on its own account and with its own resources.

This Seven-Year Plan was formally authorized by an act of the Iranian Parliament in February 1948. Its stated objects are to carry out such plans for the development of the country and its economy as will raise the standard of living and standard of education of the people, and reduce the cost of living. A seven-year program for carrying out the work within the limits of appropriations was assigned under the law. The total amount to be expended during the seven-year period was fixed at the equivalent of $670 million at current rates of exchange.

This plan originated with the Iranians themselves, and its concept is traceable back to the late 1920's. Since then, it has carried through a tremendous, though in many respects unbalanced development, which wrought wonders with the progress and economy of the country only to be interrupted and finally to fail under the impact of World War II.

Overseas Consultants, Inc., composed of eleven nationally known engineering, consulting and construction companies in this country is now in the third phase of a consulting assignment as advisors to the plan organization aimed to assist in all the manifold ways which American technical collaboration and cooperation can contribute toward the successful outcome of this almost overwhelming undertaking. The constituent companies of Overseas Consultants, Inc. are: F. H. McGraw & Co., Standard Research Consultants, Inc., Sanderson & Porter, Jackson & Moreland, Coverdale & Colpitts, the J. G. White Engineering Corp., Ebasco Services, Inc., Ford, Bacon & Davis, Inc., Madigan-Hyland, Inc., the American Appraisal Co., and Stone & Webster Engineering Corp.

The first step was a quick survey by five individuals representing most of the constituent firms of Overseas Consultants, Inc. to determine if the plan was feasible and reasonable for Iran. The second step was a detailed study of the whole economy and social structure by a group of thirty-five specialists, and a comprehensive report in five volumes dealing with each phase of the business and life of the country, with recommendations for programs. The third step, now in operation, is the establishment of a resident staff of qualified consultants in Iran whose function is to advise the plan organization. This staff is directed in Tehran by Max W. Thornburg, vice-president of Overseas Consultants, Inc., long experienced in the Middle East and in the affairs and with the governments of that area.

Great difficulties confront the plan organization. The country is somewhat larger in extent than France, Spain, Portugal, Italy, Switzerland, Belgium, and Holland combined, but its population is relatively small, approximately 17 million, or one-tenth of that of the above countries. Distances between important centers are great and

the natural obstacles of rugged mountain ranges and a vast central desert area render transportation and communication difficult.

The population is composed of a small ruling class of wealthy families, a relatively small and uninfluential middle class, and a large proportion of peasants, city dwellers, and nomads who are poor and ill-educated. Housing and living conditions, even in the larger cities, are far below modern western standards; in rural areas, they are extremely primitive.

Nowhere in the country are modern sanitary and water supply systems to be found and in most areas the standard of public health is extremely low. Facilities for the prevention and treatment of disease are inadequate; in some areas, they are nonexistent. It is estimated that 70 pct of the population is without any medical service whatsoever. The infant death rate is estimated to be about 50 pct of live births—which compares with the 1946 United States rate of 3.4 pct. Epidemics are common and widespread.

The Iranian farmer does his work without benefit of high-powered, fast moving machinery.

Education standards are low, and a large proportion of the population is illiterate. There is a need for technical education for the development of supervisors and skilled workers in manufacturing industries. Water is the life blood of the nation. The supply in some regions is inadequate, and available supplies are wasted extensively by primitive methods of distribution. Development of irrigation systems and of potable supplies for the country in general is one of the major objectives of the plan.

The topographical features of the country, which make transportation and communication difficult, have hampered distribution of both manufactured and agricultural products. It is not unusual for shortages to exist in some localities while surpluses are available in others. The need for an adequate distribution system is especially apparent in the matter of fuel for domestic use. The country has large petroleum reserves and several coal mines in active operation but the cost of distribution is so high that these fuels are not widely used for domestic purposes. Charcoal and brushwood are used instead. This results not only in uneconomical use of good timber but denudes the land of ground cover needed for retaining moisture in the soil.

Under the program initiated in the 1920's, a railroad was constructed from the Persian Gulf to Tehran and the Caspian Sea, with branches reaching toward Tabriz in the northwest and Meshed in the northeast. In the 870 miles from the Persian Gulf to the Caspian Sea it climbs first to an altitude of 9500 ft, and again to 7000 ft, crosses 4102 bridges, and passes through 224 tunnels, many of which corkscrew inside the mountains. In one spot the railroad traverses 6 bridges and 4 tunnels in a distance of 900 ft. In another, 60 out of 90 miles are through tunnels. Along with the railroad a road building program was begun, and telephone systems established. Thus, a start toward a modern communications system was made but progress was stopped by the war.

At the outbreak of the war, foreign technicians returned to their own countries and industry was deprived not only of their expert services but of necessary repair parts. During and subsequent to the war, large profits were made by private industries and in many instances, most profits were paid out as dividends, working capital was depleted, and funds for rehabilitation were not accumulated. These policies, and the tremendous demand for production caused by shortages of goods, left most of the industrial plants, mines, railroads, and communications systems in deplorable condition.

The productive capacity of the country's industrial plants, even when in good repair, is far too small to produce the goods necessary for a viable economy, and this condition is accentuated by a shortage of electric power for both industrial and domestic use. A large program of power development must be undertaken coincident with other developments.

It is an unfortunate circumstance that most of the more important industrial enterprises are owned and managed by government agencies, particularly those erected under the first program. Government-owned properties are not efficiently operated. Politics has entered extensively into management and a greater number of persons are employed than would be found in western establishments of similar size and type. Per capita production is very low, healthy competition is absent, and production costs and sell-

Iran's industrial plant is small, and the old handicrafts survive. Photo shows rug weaving.

ing prices of manufactured goods are far too high. The quality of goods produced is poor.

The reason for the preponderance of government ownership of the country's larger enterprises is not far to seek. For generations, Iranians have been trained as traders and merchants and have been accustomed to engage in enterprises in which large profits and a quick return of capital can be realized. The investments of the wealthy are largely in land, revenue-producing real estate, and relatively small privately controlled industries. Joint stock enterprises such as are universal in western countries are almost unknown. One of the strongest general recommendations of Overseas Consultants, Inc. was that the Iranian Government adopt as its long-term policy the transfer of government-owned industrial and mining enterprises to private ownership. But this will not be easy, as the idea of long term investments either in government loans or privately issued securities is virtually unknown in Iran. A large proportion of business loans, especially to smaller businesses, is made in the bazaars. The legal rate of interest is 12 pct per year but the actual rate charged on bazaar loans is generally far in excess of this. It will be necessary to exercise ingenuity to find forms of financing enterprises which will enlist the interest of prospective private investors. It may be found desirable for the government or the plan organization to make loans to new enterprises at moderate interest rates or to purchase preferred stock in them. It may also be necessary to enact new laws which, among other things, will provide incentive for private investment in industry. Happily, the government is in a sound financial position. Its external debts are small and internal debt is relatively unimportant in amount. Not only has it a substantial favorable balance of foreign exchange, but a large annual revenue in foreign exchange from petroleum property which has been developed and operated by the British owned Anglo-Iranian Oil Co. Revenue from oil should prove sufficient to furnish in large part the money needed for carrying out the plan. But until the plan has progressed to a point where production, both industrial and agricultural, can substantially meet the demand for consumer goods, the problem of inflation must be faced.

Relatively little is known of the mineralogy of the country. It has never been systematically surveyed and no reliable information of the full extent and quality of deposits is available, even for those now being worked. From general indications, it would seem that Iran is not highly mineralized, except for petroleum.

Mining operations as a general rule require relatively large investments of capital. For a successful mining venture, therefore, it is necessary that (1) a demand exist for the products either at home or abroad, (2) the products can be transported to markets at reasonable cost, and (3) the nature, quality, and extent of the deposit are such as to make possible economical operation. In this connection it should be borne in mind that in order to give employment and save foreign exchange, it may well be more advantageous to produce minerals in Iran at a cost somewhat higher than the prices at which they can be imported.

The principal mineral deposits now being exploited, exclusive of petroleum, are coal, iron, copper, lead, sulphur, and salt. With the exception of the latter two, these operations must be considered relatively small. All mines are overstaffed and overmanned. Production per worker is extremely low. The output per man in coal averages $\frac{1}{8}$ ton per day as compared with over five tons in this country.

At present no iron is produced in Iran although the ore and all other needed raw materials are available. Much money was spent before the war in developing mines in the Samnan area in anticipation of the construction of a steel mill at Karaj. The mill was not built and no use has yet been made of the ore which has been mined. Large quantities of cast iron pipe and other products will be needed for the development program, and there will be a need for the products in the manufacture of which iron is required.

Domestic requirements for copper far exceed present domestic supplies, so that the search for new copper deposits and the fostering of present mines to a reasonable extent is justifiable. New mining operations, however, should not be undertaken, until the extent and quality of deposits are known and the probable cost of production determined.

There are known deposits, generally small, of chromite, manganese, antimony and gold. In the nonmetallic minerals, magnesite appears but can not be mined economically due to location. Fireclay ample for local needs is available. Petroleum is the one great resource of the country. The Anglo-Iranian Oil Co.'s refinery at Abadan is the largest in the world. Steps are being taken by the government for exploration and development of the presumably large deposits outside of the Anglo-Iranian concession.

The successful achievement of all of the aims of the seven year plan involves much more than the preparation of technical specifications for certain projects or even of rigid regulations for the broader social and economic aspects of the plan. The analyses of existing conditions as a basis for determination of what the first projects should be or what changes in long established systems, customs or laws should be undertaken, their interrelationship and the priority with which they should proceed are the chief contributions of the Overseas Consultant's report.

The goal which the plan organization has set for itself is ambitious, and it may well be that a longer time will be necessary to complete it than has been set forth in the law. Indeed, it is probable that the program as now envisaged may have to be modified as future circumstances dictate. How the separate undertakings will interact upon one another and upon the people, and how these interactions will cause modifications in the plan cannot be mapped out in advance. But these matters are of relative unimportance. What is important is that the mere conception of the plan and the determination of the government to carry it out indicate the awareness of the government of world conditions and of the necessity for any nation which wishes to retain its independence and way of life to raise the standard of living of its people. The plan is a courageous, constructive step toward this end.

Mine Taxation

A Canadian Viewpoint

by V. C. Wansbrough

Mr. Wansbrough is executive director of the Canadian Metal Mining Assn. This paper was presented before the Mineral Economics Division at the AIME Annual Meeting in New York, on Feb. 15.

A LUCID, thorough and powerful review of the impact of your tax laws on mining operations has already been presented by Granville S. Borden*. He has brought into focus and relief the pressure-points at which the shoe pinches most, has suggested some remedial measures, and enunciated much sound doctrine about the interrelationship and interplay of taxation policy and mining activity.

Under the heading "What Every Lawmaker Should Know", he laid down the fundamental proposition that "the magnitude of our mineral resources varies inversely with the magnitude of the taxes levied upon them." With this, as with his other major premises, all mining men must be in hearty concurrence. There can be no doubt that a flourishing and expansive future for the mining industry in this country, in Canada, or anywhere else will depend on the thoroughness with which these fundamental propositions are grasped by legislators, by national policy-makers and by public opinion at large.

Coming to the specific points to which Mr. Borden has drawn our attention, I will touch on the corresponding provisions in Canadian federal tax law, by way of comparison and contrast.

A new mine in Canada is exempt entirely from taxation for its first three years of operation; in addition it is given a tune-up period of six months; so, in effect, its first three and one-half years are free from the inroads of the tax collector.

During that period it may defer write-offs for preproduction and development expenses, thereby softening the impact of taxation when it has to square its shoulders for the blow in the fourth year of its operational life. At the conclusion of the tax-exempt period preproduction and development expenses may be written off at any rate in any one year up to a fixed maximum of 25 pct.

* *See "Taxation vs Mineral Resources," by Granville S. Borden, Mining Engineering, April 1950.*

As regards depreciation of plant machinery and equipment, the regulations have recently been liberalized, and under a specific percentage limit which may not be exceeded, the taxpayer may or may not take depreciation in any one year as he pleases.

A mining company is also permitted to deduct from taxable income all prospecting, exploration and development expenditures. These are regarded as legitimate operating expenses.

Depletion allowances are provided for at the rate of 33⅓ pct of net annual profit; in the case of gold mines, 40 pct or $4 an oz., whichever is greater. There is no tie-up between depletion allowances and estimated ore reserves.

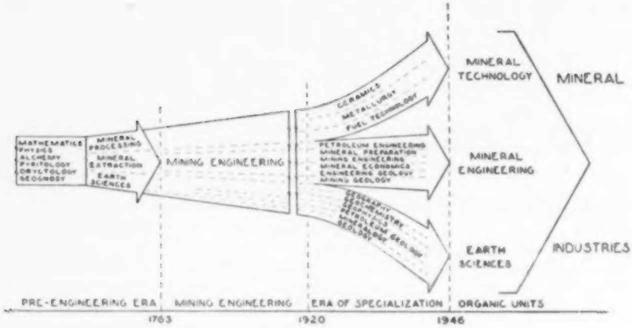
An operating loss in any year may be carried back one year or forward five years, to be offset against profits without any qualifying clauses whatever.

The shareholder is allowed a 20 pct depletion allowance on his income from mining shares. Further, by a recent regulation, 10 pct tax credit is permitted on all dividend income, a step designed to encourage Canadians to invest their savings in productive enterprise, and the first move towards getting rid of double taxation. One should add that in Canada there is no tax on capital gains.

Such, in a nutshell, is the gist of Canadian tax law as it affects mining. Some of the provisions are quite recent, indicating that the trend is in the right direction.

It is interesting to note that the recommendations of your National Minerals Advisory Council as introduced into the Senate record by Senator McCarran on January 31 closely parallel almost point by point the tax provisions now in effect in Canada.

Finally, let no one form the impression that Canadian mining men are wholly satisfied with the tax laws under which they operate. Of course these admit of great improvement. We, as you, are convinced that such improvements will be brought about only by the most strenuous efforts to inform and enlighten public opinion and to bring its force to bear on those who are ultimately responsible for the framing and the execution of tax legislation.



The Mineral Arts and Sciences

A Modern Version

by Edward Steidle

OUR citizenry must comprehend the cold, fundamental, economic truth that the ability to create wealth depends upon primary wealth; that only primary wealth can insure our economy, liquidation of our debts, national solvency, national security. And irreplaceable minerals furnish a major part of all primary wealth.

The material phase of human progress proceeds on a series of parallel fronts, all of them interdependent to some extent, Fig. 1. The rise of the standard of living, dependent as it is upon the manufacture and mass distribution of goods, is based essentially upon the development and utilization of the material resources of a country or land area. This development involves the extraction of mineral and organic products from the earth, their transportation to manufacturing centers, their transformation into finished goods, and their distribution to the people. All of these operations proceed continually and simultaneously on a parallel broad front, but each operation involves a series of stages, and each of these stages is conducted by human beings in whom qualities of intelligence, skill, and industry must be found in order to facilitate efficient consummation.

Mr. Steidle is Dean, School of Mineral Industries, Pennsylvania State College, State College, Pa.

The mineral arts and sciences have their roots in minerals and rocks—natural resources. Minerals are the primary building blocks of the earth. As far as their chemical composition is concerned, minerals can be elements such as sulphur, simple inorganic compounds such as galena, or crystals of a composition which vary within defined limits such as mica. Most of the minerals are crystalline in nature. Natural minerals are, therefore, characterized by a definite atomic structure which repeats itself regularly throughout the crystal. If the growth of the crystal is unhindered, it is bound externally by smooth and regular faces. The internal atomic structure gives to the mineral its characteristic physical properties, such as form, color, and hardness. A rock is an aggregate of certain characteristic minerals which forms an important part of the earth's crust. Mineral resources, as we know them, occur as economic concentrations in certain types of rocks, in solution in the sea, and as gases in the atmosphere. The carbonaceous materials coal, petroleum, and natural gas are identified as mineral fuels.

Assaying, mineralogy, and geology appear in ancient records as early as mathematics, physics, and chemistry. Agricola was the first author to unify the earth sciences, the mineral extractive industries, and the mineral processing industries.

Early mining engineering education, 1763-1900, was expected to cover all eventualities in the mineral industries (see cut, above). Optional curricula were offered early in the 20th century but did not reach into all branches until after World War I. Specialization crystallized during World War II under three organic units: (1) **Earth Sciences;** (2) **Mineral Engineering;** (3) **Mineral Technology**, the three together constituting the mineral arts and sciences of the modern world.

The Earth Sciences are concerned with those divisions of natural science which relate specifi-

cally to the earth, its origin, constitution, and evolution. The term Earth Sciences is a direct translation of "geo-ology."

Mineral Engineering is concerned with extracting minerals from the earth and preparing them for use. In other words, it is the means by which mineral matter, including mineral fuels, is made available to man.

Mineral Technology is the applied systematic knowledge of primary methods of processing and treating mineral matter and directing its industrial utilization. It is concerned with those industrial arts and sciences which involve the transformation of mineral fuels into energy and the conversion of minerals of all classes into raw materials or finished articles.

Various fields of learning that are indispensable to the locating, beneficiating, processing and using of minerals cannot be classified properly as engineering. For example, in locating deposits, the sciences of paleontology, stratigraphy, mineralogy, petrology, petrography, geochemistry, economic geography, and mineral economics might be involved. Beneficiating, processing, and using go beyond the normal scope of engineering to include fuel technology, physical and organic chemistry, physical and atomic metallurgy, and ceramics.

The mineral arts and sciences are interrelated, interdependent subject matter fields similar to agriculture. The use of mineral engineering as an all inclusive term is contrary to the truth and results in dismemberment, confusion, and overall inefficiency. Ill-conceived proposals of this character constitute acts of sabotage on the well-being of the people, as well as on the mineral industries. The idea is a hangover based only on tradition and indicates ironically the fallacy of being tied to the apron strings of the Engineering Foundation. Earth scientists, mineral engineers, and mineral technologists must unite now for the common good.

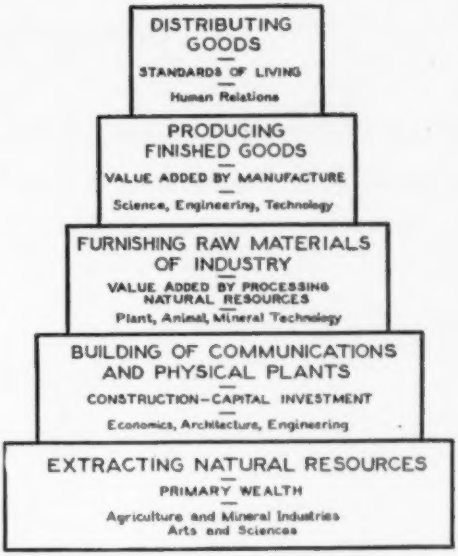


Fig. 1: The material phase of human progress, showing the five stages of applied science, engineering, and technology.

Books for Engineers

Annals of the First Pan American Mining and Geology Congress. This volume contains all the scientific papers, including illustrations, presented at the Congress which was held in 1942 in Santiago, Chile. The work consists of five volumes, with 2316 pages, is priced at $5. Write directly to Instituto de Ingenieros de Minas de Chile, Clasificador 671, Santiago de Chile, and enclose payment with your order.

Coal, Coke, and Coal Chemicals. By P. J. Wilson and J. H. Wells. McGraw-Hill Book Co., 1950. 509 pp., $8.00.

This text is an authoritative treatise on coal, high-temperature coking, recovery of coal chemicals from coke-oven gas, and distillation of tar. Each phase of the industry is systematically covered, and other coal-carbonization processes, gas retorts and lower-temperature coking are briefly described. Fuels in general, and the principles of combustion as well as the economics of the industry are considered. A bibliography and a list of visual aids are included.

Industrial Minerals Handling. By I. M. Footlik, C. F. Yarham, and J. F. Carle. Lincoln Extension Institute, Cleveland, Ohio. $4.75. Designed to fill a need for a comprehensive treatment of materials handling in industry, this book brings together in one volume the basic principles, practices, equipment, and applications of materials handling. It contains over 100 practical illustrations, a fundamental section on time and motion studies, as well as tables, problems, and study topics.

USBM Films Available. The U. S. Bureau of Mines reminds us that 13,000 reels of film, covering more than 85 subjects, are available to interested groups across the nation. These films cost more than $5 million to produce, which sum was largely appropriated by private industry. Last year more than 12 million persons attended showings on subjects ranging from "The Drama of Steel" to "Magnesium Metal from the Sea." A catalog listing of all Bureau films is available from the Central Experiment Station, 4800 Forbes St., Pittsburgh, Pa. There is no film rental charge, the user merely paying the cost of shipment.

Applied Sedimentation. Edited by P. D. Trask. John Wiley & Sons, New York, 1950. 707 pp., $5.00. Containing 35 original articles prepared by specialists, this practical volume describes aspects of mutual interest to the geologist and the engineer. The articles are grouped under the following headings: basic principles of sedimentation; engineering problems involving strength of sediments; applications of processes of sedimentation; applications involving nature of constituents; economic mineral deposits; petroleum geology problems; and military applications. A list of references accompanies each article.

Plastic Pipe Completes 20-Month Test, Combats Acid, Proves Easy to Handle

More than 6000 ft of Carlon "E" pipe, made by the Carter Products Corp., has completed rigorous 20-month tests in three of the nation's leading mines, and come through with flying colors, according to the manufacturer. The pipe showed no signs of wear, and resisted all deterioration by acid mine waters. One mine superintendent estimated that iron pipe would have been replaced a half dozen times during the same service period. The new pipe has a tensile strength of about 1400 psi and a flexural strength of up to 1700 psi. It curves easily to conform with irregular floor and wall contours, and to follow entry directions. A 100 ft length of 2-in. diam Carlon "E" weighs about 90 lb, and can be handled by one man, who can lay the pipe and make joints in as little as 2 min. The elasticity of this pipe exceeds the percentage of expansion of freezing water, acts as an insulator, and also eliminates the problem of electrolytic corrosion. (Circle No. **40**)

Portable Ultra Violet Lamps

Two new portable models of their ultra violet lamp, the **MINERALIGHT**, are now being offered by the Stratex Instrument Company. These lamps are versions of the **MINERALIGHT** which was instrumental in discovering $100 million worth of scheelite during the war. The new portable models weigh only 1 lb, and can be operated in the field on current from two 45-v "B" batteries. (Circle No. **41**)

LESS BATTERY CHARGING

Two-shift shuttle car operation without changing batteries is now possible. Gould Storage Battery Corp. has introduced 400-amp-hr batteries and a new booster-charge method which makes it possible to use only one set of batteries per car during a two-shift operation without recharging. (**43**)

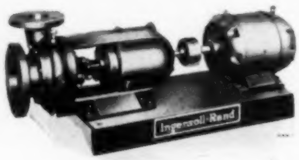
Ingersoll-Rand Features Three New Products

Three new products have been announced by the Ingersoll-Rand Co. — an attachment for the Carset Jackbit, a new type of air compressor, and a new line of cradle mounted centrifugal pumps.

The Jackbit attachment enables users to realize full drilling economies of tungsten carbide bits because it has the same life as the bit itself. It has 38 reverse-buttress threads to absorb destructive reciprocating and rotational forces, and more metal has been added to the skirt walls of the Carset Jackbit. It is available in four sizes in the 1⅜ to 3 in. range.

The air compressor, known as the XLE, has a single low pressure compressor cylinder, a horizontal high pressure cylinder, and a synchronous motor on the crankshaft. It requires only a small foundation and, according to the company, is "engineered full of new ideas." One innovation is a new airflow scheme which eliminates interstage piping and cylinder strain.

A four-page booklet on the salient features of Ingersoll's new **cradle-mounted pumps** is available from the company. They are built



in 5 different sizes, single and two-stage, with capacities up to 1600 gpm and heads up to 250 ft. Horsepower range is from ¼ to 75. They may be driven by direct electric motor, electric motor and V-belt, turbine through reduction gears, direct turbine, V-belt gasoline engine or direct gasoline engine.

For more information about these Ingersoll-Rand products, circle No. **44** on the coupon on p. **777**.

Improved Flexible Tubing

Flexible Tubing Corp., Branford, Conn., is offering a newly improved type of lightweight flexible tubing, said to be highly wear and heat resistant, portable, retractable, and easy to assemble. Weighing only 0.64 lb per lin ft, it features built-in coupling which permits 10-sec jointing without tools or accessory fittings. It is designed to satisfy most ducting requirements from 3 to 30 ft ID for air and other gases, as well as powdered, granular, or other light solids. The tubing, known as "Spiratube," consists of a rust-proof, spring-steel helical core covered inside and out with a double-seam stitched cotton duck, coated with neoprene. Standard variations include multiple-ply walls and various coatings as needed. "Spiratube" was originally developed for the Navy. (Circle No. **42**)

NEWS FLASHES

• Heavy-media separation is now being used on a large scale to recover diamonds from blue ground in South Africa. The Premier Diamond Co. Ltd., Transvaal, is using one of the largest hms plants in the world, with a feed rate of 13,000 tons per day. (Circle No. **45**)

• Bausch & Lomb has developed a new microscope for quantitative analysis of ore samples which will handle opaque specimens up to 4 in. square. (Circle No. **46**)

• Western Machinery Co. has announced the sale of two prefabricated heavy-media separation plants to Charbonnages d' Hensies Pommerouel in Belgium. One will treat 200 tph of 80 x 6mm feed, and the other will handle 100 tph of 6 x 2mm coal feed in a Wemco Cone Separator. (Circle No. **47**)

• An almost completely automatic conveyor system for moving and mixing gold, silver and lead ores has been installed in the proportioning plant at the **AS&R** smelter in Selby, Calif. The motors are controlled by eight remote push button stations which are tied together through two General Electric motor control centers. Master control of conveyors, elevators, crushing rolls, feeders and vibrators is possible from any one of the eight stations. (Circle No. **48**)

• Newest soldier in the fight against air pollution is Pennsylvania's mobile laboratory, armed with 25 devices for field sampling and analysis of atmosphere in communities and factories. It was produced by the Mine Safety Appliance Co., and is the first of its kind ever constructed. (Circle No. **49**)

Free Literature

For your convenience, a listing of booklets and other material currently being offered by the manufacturers. To obtain this information, merely circle the desired number on the coupon, and return it to *Mining Engineering*.

1) FLOTATION AGENTS: Up-to-date information on new, as well as familiar *Hercules Powder Co.* flotation agents and applications is contained in a new technical booklet. Descriptions and functions of the three divisions of flotation agents, frothers, collectors and modifiers are discussed. Mathematical formulas useful in the operation and control of modern ore-dressing mills are included in the appendix.

2) ROD MILLS: Revised literature on rod mills for grinding and pulverizing has been published by *Hardinge Co., Inc.*, in bulletin 25-B. A number of typical installations as well as details of construction of the various models, specifications and performance data are shown.

3) WIRE ROPE: Cross-sectional illustrations of the different types of Wickwire rope manufactured by *Colorado Fuel & Iron Co.* and descriptions of the various applications of the grades manufactured are shown in the company's bulletin. Many of the other products made by CF&I are also illustrated.

4) DIAMOND DRILLS: A new 34-page booklet distributed by *Christensen Diamond Products Co.*, lists all equipment and supplies for diamond drills. The first section of the booklet illustrates the part, gives OD and ID dimensions and weight of part. The second half lists the part name, number and price.

5) BLOCK SIGNALS: To help stress the importance of safety-first in the mining industry, *Nachod & United States Signal Co.*, has printed a booklet describing their line of automatic signals for use in mines. Greater protection is afforded by automatic signals because the human element in the operation of signals is eliminated.

6) FLOTATION MACHINES: Bulletin No. 482 describes the new *Morse Bros. Machinery Co.* Jetair flotation machine. The different machine sizes and individual components are illustrated. These machines perform efficiently on any flotable material with the particular chemistry that is applied. A more thorough mixture of pulp, air and reagents is produced.

7) ROOF BOLTS: This method of roof support makes more space available for moving machines and there is no danger of knocking down supporting beams. Bulletin 293 offered by *Bethlehem Steel Co.* illustrates the advantages of roof bolting.

8) VALVES: The increasing use in industrial processing of mine water, sludges, slurries and other corrosive fluids makes absolute tightness around the stem a necessity. The improvement on conventional packless valve design is described in a new bulletin distributed by *Crane Co.* No packing is needed to seal the bonnet around the stem of this newest development in diaphragm valves.

9) BLOWERS: Centrifugal and rotary positive blowers and exhausters, liquid and vacuum pumps and inert gas generators and other equipment for handling air and gas are described in bulletin G-82 printed by *Roots-Connersville Blower Corp.* The equipment can be adapted to electric motors, dc, speed changer, V-belt, gas engine or steam turbine.

10) LUBRICATION: To aid in keeping machines running at top performance, *Lubriplate Div., Fiske Bros. Refining Co.*, has incorporated recommendations for proper lubrication of machines used in the various industries in a new booklet. Individual lubricants for different types of equipment are listed.

11) JIGS: The Dorrco Pan-American pulsator jig, used for roughing and cleaning in both open and close circuit milling of gold ores, is described in a new 6-page, two color *Dorr Co.* bulletin. Photographs, drawings and a table of dimensions for both the single and double hutch models are shown.

12) DIAMOND DRILL BITS: Used by mining engineers and drill operators for 40 years, Truco diamond drill bits solve difficult and unusual problems. Custom built for jobs, many formations have been drilled that were considered unsuitable for diamond drilling. Core bits, blast hole bits and others are illustrated in this insert pamphlet offered by *Wheel Trueing Tool Co.*

13) ELECTRICAL MAINTENANCE: A series of articles on the care of ac rotating equipment has been made available in booklet form by *Allis-Chalmers Mfg. Co.* Drying moist insulation, measuring insulation resistance and proper machine applications are just a few of the subjects covered in bulletin 05R7417.

14) DIPPERS: Bulletin 547 DS offered by *American Manganese Steel Div., American Brake Shoe Co.*, contains information on parts for shovels and draglines. Instead of wearing out after long and steady use these dippers get harder and take on a high polish for added wear resistance.

Mining Engineering
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July

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15) CLASSIFIERS: The four outstanding advantages of *Western Machinery Co.'s* model S-H are stressed in bulletin C-1 S-1. The same bulletin also describes the many other classifiers manufactured by Western.

16) WELDING RODS: Tobin bronze and all other Anaconda welding rods are described in the 17th edition of publication B-13 from *American Brass Co.* These tobin bronze rods are low-cost, low-temperature for oxyacetylene welding. Procedures on how to weld are also included.

17) ROCKERSHOVELS: RockerShovels made for every need are described in bulletins offered by *Eimco Corp.* Bulletin L1017 has information on drawholes, L1018 on wide headings and L1005A on tunnels. These shovels are easy to operate, faster in loading the cars and stronger for lifting heavy muck.

18) FEEDERS: A steady flow of material using Traylor feeders increases crusher production. Bulletin 1114 describes the advantages of using *Traylor Engineering & Mfg. Co.* feeders. A controlled feed of material gives more production with less attention and there are no peaks and valleys in the supply.

19) FIRST AID EQUIPMENT: Complete first aid units for easy transportation in the mine are described in bulletin 103 offered by *Mine Safety Appliances Co.* Packed in a 20-gage steel case the equipment is kept dry and free from dirt and mildew. It is especially adapted for storage at the working face.

20) PUMPS: Hydrosealing, a method exclusive with *Allen-Sherman-Hoff Co.*, keeps abrasive-laden water from between the pump's impeller and sideplates. Pumping systems made to individual needs will assure maximum production and efficiency. After the system has been installed it is followed up systematically as to the performance.

21) PLACER JIGS: *Yuba Mfg. Co.* will build special equipment to order, just send in blueprints or specifications. The drives for the jig pulsators are completely enclosed, avoiding the entrance of dirt and dust in the oil. Many advantages are listed, just write for bulletin.

22) V-BELTS: Bulletin MV-201 offered by *Maurey Mfg. Corp.* describes their multiple V-belts and provides a complete price list and comparison table for the five section sizes. Similar data is provided on special sizes for replacement only.

23) CONE CRUSHERS: Symons cone crushers manufactured by *Nordberg Mfg. Co.* are available in three types, standard, short head and intermediate, one of which will suit all needs. Further details are available by writing to Nordberg.

24) ELECTRIC MOTOR CONTROLS: For easy installation, operation and servicing, the *General Electric Co.* synchronous control is mounted in a steel enclosure with all the built-in accessories required. Bulletin GEA 5332 is for low speed, GEA 5426 for high speed and GEC 505 for control.

25) SUMP PUMPS: Designed on a new principle, the VP4 sump pump manufactured by *Gardner-Denver* is described in the company's latest bulletin. Breaking of the pump shaft seal because of water pressure, one of the most common causes of pump failure, is eliminated by top-suction.

26) SLUSHERS: Interchangeability of drives to suit conditions is but one of the salient features of slushers manufactured by *Joy Mfg. Co.* Air-powered or electric installations are available. Bulletin describes the various models available.

27) FLOTATION INDEX: The 20th annual additions to the flotation index are now available from *Great Western Div., Dow Chemical Co.* This handy booklet gives the most complete and authoritative guide on all flotation process material that has been published to date.

28) HEAVY MEDIA PROCESSOR: *Nelson L. Davis Co.* offers catalog 148 which tells the story of heavy media separation. Full seam mining has increased the need for mechanical preparation of coal produced for various markets. The Davis Processor is illustrated in various stages of its use.

29) CARSET JACKBIT: Carboloy-set bits are outlasting steel bits by a wide margin as described in catalog 4091 available from *Ingersoll-Rand.* Actual field experience has given proof of what Carset jackbits can do under all conditions.

30) LOCOMOTIVES: Built by *Goodman Mfg. Co.*, locomotives in various tonnage classes are described in bulletin CL-491. Fast hauling of heavy loads is facilitated and they are available in trolley, storage battery or combination types.

31) COAL CUTTER BITS: To augment the need for a concise booklet on carbide tipped mining tools, *Carboloy Co., Inc.*, has issued catalog CM-100. This 22-page catalog contains information on tools such as finger bits, auger drill bits, and many others. Sizes, prices, specifications, and all other pertinent information are also covered.

32) CONVEYORS: Bulletin published quarterly by *Stephens-Adamson Mfg. Co.* illustrates the many uses to which conveyors made by S-A can be put. They are used in food plants, chemical plants, industrial plants and handling coal from cars to storage.

33) PACKAGED WASHERY: *McNally Pittsburgh Mfg. Co.* offers bulletin 450 which contains layout and flow diagrams for installing their packaged coal cleaning plant. The washer and housing are offered in one unit. With this equipment the customer's most exacting requirements can be met by the smaller tonnage operators.

34) COMBINATION UNIT: A crane and pile driver combination unit is described in bulletin 81 offered by *Orton Crane & Shovel Co.* Only one spotting and one operator are necessary to drive piles and set caps and trusses. Their model B3 pile driver is also illustrated.

35) GEARMOTORS: Bulletin B250 describes a new line of gearmotors *Abart Gear & Machine Co.* is announcing. Information on standard speeds and ratios, sizes, ratings and prices on single-phase and three-phase models is discussed.

36) CABLE CONVEYORS: Many industries are discovering the advantages gained by using cable-type overhead trolley conveyors. Bulletin 41 describes and illustrates the varied uses to which *E. W. Buschman Co.* cable conveyors can be put. Condensed data on trolleys, tracks, idler turns, vertical S-curves, drives and quick vertical dips are given.

37) PROTECTIVE COATINGS: Data sheet C-11 distributed by *Carboline Co.* describes Polyclad, a polyvinyl chloride coating system. The results of four years laboratory research, field testing and observations are mentioned in this first formal announcement.

38) SCIENTIFIC SUPPLIES: To help relieve eyestrain that accompanies engineering and drafting work, *Berger Scientific Supplies, Inc.*, manufactures protractors, T-squares and various instruments in eye-rest green lucite. Catalog A illustrates this entire line and also slide rules, triangles, ruling pens, dividers and all other instruments.

39) BLADELESS PUMP: The most outstanding advancements in bladeless pump design are incorporated in *Fairbanks-Morse & Co.* sewage and trash pumps. A 16-page bulletin, No. 5400k-1 illustrates the models available. Details of construction, cross-sectional diagrams, dimensions and selection tables are included.

Effect of Waste Disposal of the Pebble Phosphate Rock Industry in Florida on Condition of Receiving Streams

by Randolph C. Specht

A two year study was made of the waste disposal of the pebble rock phosphate industry. Solid slimes are impounded in large settling areas and the process water is re-used. Clear effluent was not found to be toxic to fish or animal life in field tests or in controlled experiments.

Survey: The pebble rock phosphate mining and washing operations in Florida (fig. 1) are along the river basins of the Alafia to the west and the Peace to the east. The elevation of the area varies between 40 and 170 ft above sea level. Effluents from the operations find their way into one of the two river systems (fig. 2), the Peace River which flows into Charlotte Harbor and the Alafia into Tampa Bay, both along the Gulf of Mexico.

There are no major industries along these rivers below the phosphate operations. On the Peace River, the town of Arcadia, approximately 50 miles below the phosphate operations, obtains its water from the river. No other communities along the rivers use them as a source of water supply. Small communities, farms, and ranches are located along the rivers and both rivers drain vast swamp areas.

RANDOLPH C. SPECHT, Member AIME, is Professor of Chemical Engineering, Research Engineer, Engineering and Industrial Experiment Station, College of Engineering, University of Florida, Gainesville, Fla.

AIME Tampa Meeting, November 1949.

TP 2878 H. Discussion (2 copies) may be sent to Transactions *AIME before August 31, 1950. Manuscript received March 8, 1949; revision received Oct. 31, 1949.*

Complaints had been received at the office of the Chief Sanitary Engineer, of the Florida State Board of Health,[1] that both rivers were turbid at various times and that fishing in the Alafia River was "not as good as it used to be." Tests made by another agency on the dissolved oxygen content of the Alafia River revealed that the oxygen content, at times, was comparatively low.[2] However, it was not shown that the phosphate wastes had any effect upon the oxygen content of the stream.

The river waters are normally brown in color due to drainage from vast swamp areas and are very shallow, from 2 to 6 ft in depth. Turbid waters have been noted in streams coming from the present phosphate operations and also from streams along which there are no operations at the present time. It was learned from "old timers" that, when many more companies than at present were operating along both the Alafia and Peace Rivers forty or fifty years ago, no attention was paid to prohibiting the disposal of slimes along the river basins. During dry periods now in some of the river swamps where drainage ditches have been dug, it is indicated clearly that phosphate slimes were disposed of directly into the river swamps for many years past. Places have been observed where there were alternating strata of phosphate mud, leaf mold, and quartz sand.

The former practice of indiscriminate disposal of wastes accounts for some turbidity, particularly after heavy rains and washouts and during clearing of land and digging of drainage ditches. During a six months' period in which a large tract of land was being cleared and drainage ditches dug, a small stream (Six Mile Creek), which previously had been clear, showed a turbidity of 600 ppm and remained turbid until the clearing was completed; after which the stream again flowed clear.

An interview with the operator of the municipal water plant, which is about 50 miles below the phosphate operations on the Peace River and which used this river as a source of supply, revealed that there had been no taste in the water for the past ten years, other than that occasionally encountered from increased growth of algae.

The operations of each of the cooperating com-

This page of Transactions AIME is a continuation from p. 718. The missing pages appeared in Mining Engineering.

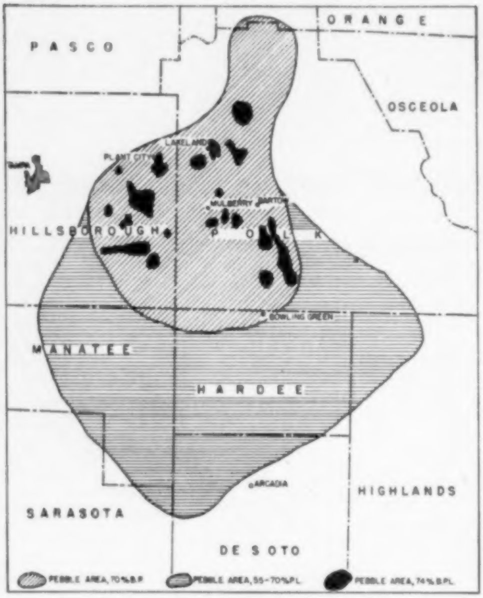

Fig. 1a—Map for insert in fig. 1b.

Fig. 1b—Florida land pebble phosphate district.
(From U.S.G.S. *Bull.* 934, plate 5.)

panies were visited and studied. A flowsheet of the processes was made and all materials used in the processing recorded. Water consumption data were collected and recorded and a sketch was made of the settling areas and waterways noting the direction of flow. All spillways and effluents were located on the sketches, as well as drainage ditches and streams flowing through and from the operation.

Sampling stations were located on all streams and drainage ditches into which effluents were discharged. These stations were above and below the operation so that the condition of the water downstream from the operation could be compared with that upstream.

No record of a fish census of either the Peace or Alafia Rivers could be found at the State or Federal Agencies.

Clay Suspensoids: Suspensoids in the water from mining and washing operations are due to clay in the phosphate deposit, from 15 to 40 pct being clay. The survey has indicated that slimes from mines in the Peace River Valley will settle if given sufficient time and that settling of these slimes is feasible and accomplished in the large areas provided. At some of the operations in the Alafia River Basin, a slime was encountered which did not settle in a reasonable length of time in the areas provided or even in a larger area, and coagulants were used to facilitate removal of the suspensoids.

An examination of the geological formation[3] of these areas does not reveal any unusual difference in the formation or drainage areas that might account for the difference in the physical characteristics of the clay. Prospecting samples taken in the Alafia area are similar in appearance to those obtained in the Peace Valley Section.[4]

A partial chemical and spectrographic analysis was made of a representative semicolloidal slime taken from an operation in which the slime settles in the settling areas provided, and from one in which the slimes do not settle readily. The slimes were separated by filtration and dried at 100°C before being analyzed.

The analyses are shown in table I.

Sufficient information was not obtained from the various analyses to determine the cause of the nonsettling characteristics of some of the slimes. The chemical analyses indicated that it may be partially due to the presence of free alumina in kaolinite. However, a thermal analysis did not identify a characteristic mineral but rather what appeared to be a mixture.[5] The slimy characteristics of the suspended clay would seem to indicate the presence of hydrous oxide lattices in the form of hydrogels of high bound water content. The nonsettling characteristics indicate the presence of a negatively charged colloid, and its presence was shown in a determination of migration velocity in the classic U-tube conductivity cell used by Burton.[6] An electrophoretic study of the migration velocity of the colloidal particles, using the Mudd cell under a microscope, showed that the nonsettling clay had a greater negative charge than the one which settled. By the addition of a proper electrolyte the charge was reduced and the clays agglomerated and settled.

An examination of the flotation chemicals used and analyses of the water in which the clay was

Table I. Analyses of Semicolloidal Slimes

Elements Analyzed for:[a]	Reported as:	Slimes Which Settled	Slimes Which Did Not Settle
Si	SiO_2	33.84	27.24
F	F_2	0.46	0.80
Al	Al_2O_3	26.32	31.30
Fe	Fe_2O_3	4.18	1.58
Ca	CaO	17.36	20.22
Mg	MgO	1.28	1.25
P	P_2O_5	6.06	6.38
	Ignition loss	10.21	11.62

[a] The spectrographic analysis, which did not cover the entire band, showed in addition to the elements listed above, the presence of small amounts of manganese, chromium, vanadium, barium, strontium, and titanium.

suspended revealed that when the clay settled, enough electrolyte, in this case calcium sulphate, was added to the water from the process to give sufficient neutralization of the negative charge to allow coagulation and settling. Where nonsettling slimes were encountered, they could be made to settle by the addition of the proper electrolyte.

The cost of chemical coagulants for treatment of the water, where required, varies with the particular deposit and process. Estimated costs have varied between \$10.00 and \$70.00 per 16-hr day for a flow rate of 18,000 gpm.

The analyses and examination of the suspensoids do not indicate any poisonous or deleterious material in them.

Turbidity: The greatest problem of waste disposal in the industry is the disposition of slimes which are removed from the process waters so that the waters may be recycled through the system. When the slimes do not settle completely, turbid waters are recycled throughout the plant and the effect on production is lower quality material and increased costs. It is therefore of considerable importance to have clear water for the washing and flotation operations, and large hydroseparators and settling areas are provided for this purpose. In addition to the interest in economy of operation and production, the industry is also interested in preventing turbid waters from entering the water systems of the State.

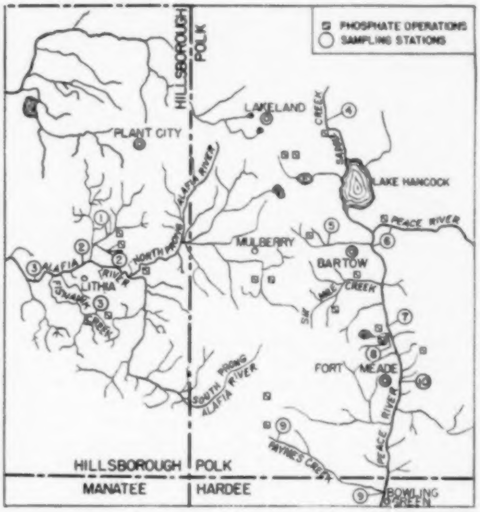

Fig. 2—Map of Alafia and Peace River Basins.

At the present time all of the plants recycle the water and during normal rainfall and operation an estimated maximum of 10 pct of the total water used may be discharged from the settling area. During heavy rainfalls, 2 to 4 in. within a few hours, the water falling into the settling areas must be discharged through the spillways to prevent washout of the dams. A heavy rainfall does not mean necessarily that turbid waters will be discharged from the settling areas; generally the settling pond is not stirred up and only clear water is discharged.

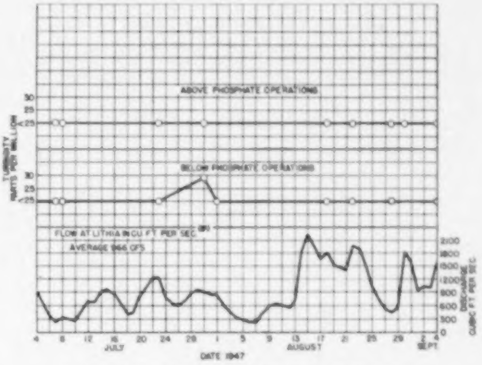

Fig. 3—Turbidity and flow of Alafia River.

As in most industrial operations, emergencies and errors of personnel sometimes result in the discharge of turbid waters.

During the period July 1 to Sept. 4, 1947, samples of water were taken from the water systems of the operations and from the streams above and below the phosphate operations. Turbidities of the samples were measured in the Jackson turbidimeter and recorded. Since the turbidimeter does not give values less than 25 ppm, any value less than this was recorded as "less than 25 ppm." The water in the streams and rivers is brown in color due to organic material, and no correction was made on turbidity for color.

Fig. 3 shows the turbidities of the Alafia River for the period. The flow of the river at the U. S. Geological Survey gauging station at Lithia, is shown on the graph.

One of the operations, at station 1, along this river was abandoned a few weeks before sampling was begun and another, at station 2, on July 15. Several operations remained along the North and South Prong.

On July 30, a turbidity of 29 ppm was recorded on the sample taken from the river below the phosphate operations. On this date the North and South Prong were clear; operations on the branch that was turbid were abandoned and the source of the turbid waters was not located.

It is of interest to note that during the time of heavy rainfall and high waters there was no marked increase in turbidity of the waters in the river.

One of the operations that encounters slimes that are difficult to settle is located on Fishhawk Creek. At this operation lime is used to aid the coagulation and settling of the suspensoids. Normally all the water is recycled throughout the system but in times of heavy rainfall it is sometimes necessary to discharge water into the creek, and the water may or may not be turbid, depending upon many factors.

Fishhawk Creek flows from a swampy lowland area approximately two miles above the effluent of the plant. The creek is very turbid during the rainy season and shows the effects of soil erosion. The flow of the creek above the phosphate operation during the dry season was estimated at less than 1 cu ft per sec; during heavy rains it became a rapidly flowing stream.

Table II shows the turbidity readings obtained from samples taken from the creek at points above and below the phosphate operations on the dates

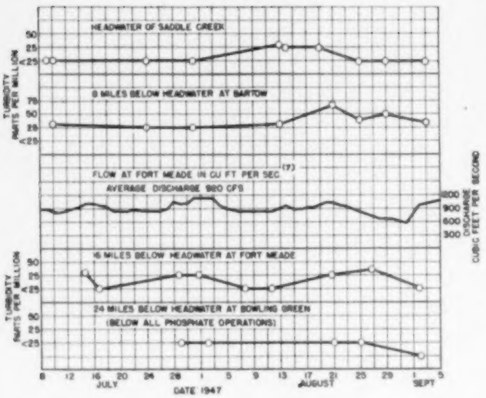

Fig. 4—Turbidity and flow of Peace River.

indicated. It is noted, with one exception (July 23), that the stream above the operation was more turbid than below. There is no doubt but that the industry may add to the total load on the stream but it is to be observed that the present industry is not responsible for the entire condition of this stream.

Samples taken from the Alafia River, two miles below the mouth of Fishhawk Creek, showed turbidities of less than 25 ppm during the same period, thus indicating that the small amount of turbid water from the creek did not materially affect the turbidity of the river.

Fig. 4 shows the turbidity of samples taken from the Peace River Basin and the flow of the river at Ft. Meade. Turbidities are shown for the stream above phosphate operations (Saddle Creek) and at approximately eight mile intervals along the stream. The last station was about four miles below the last operation. The source of a part of the turbidity of the stream, particularly at Bartow, was traced to phosphate operations. There appears to be no direct relationship between turbidity and flow in the stream.

Over 500 measurements were made on samples of the rivers and tributaries during the period of the extensive test. From data obtained it was calculated that with the dilution of the effluent of 1 to 29.5, the receiving river increased in turbidity in an amount equal to 2.5 pct of the turbidity of the effluent; 25 pct of the suspended solids were deposited on the stream bottom; and the remainder, 75 pct, was carried in suspension a distance of at least three or four miles. It would not follow necessarily that this is always the case, because the nature of the suspended matter and the diluting water may be such that there would be coagulation and precipitation in comparatively short distances.

Dissolved Oxygen and Biochemical Oxygen Demand: During the period of the test, 519 samples were analyzed for dissolved oxygen (D.O., elementary oxygen dissolved in a water) and biochemical oxygen demand (B.O.D., the amount of oxygen required to oxidize biologically the organic matter in a waste over a stated period of time) by the standard method.[9] All results are reported in parts per million and the B.O.D. as the "five day-twenty degree Centigrade." Normal river water, into which the effluent or waste flowed, was used as a dilution water for the B.O.D. determination.

In all cases the D.O. content of the effluent of settling areas was found to be higher than that of the receiving river. The B.O.D. content of the river water at Bowling Green, below the operations, was found to be lower than at any point along the stream, except at station 6 where it was the same.

Although the B.O.D. of the effluents of some of the operations was found to be 1 ppm higher than that of the receiving streams, the pounds of B.O.D. added is comparatively small, amounting to only 0.15 pct of the increase in the load in Peace River between Bartow and Ft. Meade, as shown in table III. Many small streams into which no effluents were flowing were found to have a higher B.O.D. than the effluents.

Table II. Turbidities of Fishhawk Creek

Date 1947	Above Operation, Ppm	Below Operation, Ppm
July 1		136
July 2	1,450	190
July 3	3,500	220
July 7		160
July 8		140
July 23	31	63
July 30	170	140
Aug. 18	250	35
Aug. 22		50
Aug. 28		215
Sept. 1	160	
Sept. 4	110	< 25

The results indicate that the dissolved oxygen content of the stream is improved and the biochemical oxygen demand is not materially changed by the effluents of phosphate operations.*

* Detailed results of the D.O. and B.O.D. tests will be published elsewhere.

pH of Streams and Effluents: The pH of effluents of the operations was found to be substantially the same as that of the rivers. Some of the small streams above the phosphate operations were more acid than the rivers, particularly the streams at the head of Alafia River and at the head of Fishhawk Creek. In Fishhawk Creek the effluent of the phosphate operation had the effect of bringing the pH of the water near to the normal for the river into which it emptied. Table IV shows the minimum and maximum values of pH in the streams. Over 500 determinations were made during the test. The glass electrode was used for all determinations.

Table IV shows a wide variation in the minimum and maximum values of pH from all the operations. However the pH of each individual operation varied only slightly, and the effect of the effluent on the pH of the receiving stream was not measurable except in Fishhawk Creek where the effluent was considered to be beneficial.

Laboratory Tests on Minnows and Small Fish: Laboratory tests were made on live minnows which were placed in water containing flotation chemicals and in waters taken from the effluents of various phosphate operations. When flotation chemicals were used, the chemicals were added to water taken from the Peace and Alafia Rivers in an amount such that the dilution would be the same as in a plant, provided all the flotation chemical passed into the effluent of the settling area. This, however, is not the case in any of the operations as is shown later.

Table III. Increase in D.O. and B.O.D. of Peace River due to Effluent from Phosphate Operations

	Flow* in Cu Ft per Sec	D.O., Ppm	D.O., Lb per Day	B.O.D., Ppm	B.O.D., Lb per Day
River at Bartow	683	2.74	9,750	1.4	5,175
Effluent No. 7 (16 hr day)	3.3	6.82	12	2.1	3.5
Effluent No. 8 (16 hr day)	12.2	5.86	36	2.4	1.5
River at Ft. Meade	920	4.24	21,050	1.6	8,110

Increase in flow due to combined effluents, 4.3 pct
Increase in D.O. due to combined effluents, 0.15 pct
Increase in B.O.D. due to combined effluents, 0.15 pct

* Flow of river based on average flow for the period July 1 to Sept. 4, 1947.

All tests were made at 19.5° to 20.5°C (67° to 69°F). Glass jars were used as containers. Water was aerated continuously and kept within the temperature range by placing the jars in a constant temperature water bath. The test water was not changed during the test. The fish were fed periodically with ground puppy (dog) food.

Minnows used for the tests were obtained locally from a swamp area and were the Gambusia affinis holbrookii, Molliensis latipinnis and Heterandria formosa. One small bream was used in one of the tests.

The concentration of flotation chemicals used in the test waters is shown in table V.

Results: When minnows were placed in the test water containing the chemicals shown in table V, there was a complete kill after 48 hr. When the fuel oil, tall oil and kerosine were emulsified in the test solution by mechanical means, the kill was reduced to 6 hr, probably due to thorough dispersion of the tall oil in the water. When only amine acetate was used in the tests, the minnows lived for nine days, the duration of the test.

When samples were taken from (1) phosphate float water, and (2) from a flotation water settling area and used for a test, there were no kills of test animals during the 25 day period of the test. In a test using water from a settling area having a turbidity of 50 ppm, there were no kills during a 14 day test.

Table IV. pH of Rivers and Streams

	Minimum	Maximum
Alafia River at head (station 1)	5.9	6.9
Alafia River at Lithia (station 2)	6.1	6.9
Alafia River (station 3)	6.8	6.8
Fishhawk Creek above phosphate operation	4.8	5.6
Fishhawk Creek 2 miles below operation	5.8	7.1
Fishhawk Creek phosphate effluent	6.1	6.6
All phosphate effluents in Alafia River Basin	6.4	7.1
Peace River at head (station 4)	6.0	6.4
Peace River at Bartow (station 6)	6.1	6.3
Peace River at Ft. Meade (station 10)	6.4	6.8
Peace River at Bowling Green (station 9)	6.3	6.4
All phosphate effluents in Peace River Basin	6.1	7.4

Conclusions from Laboratory Tests: The results of the laboratory tests indicate that tall oil is the most toxic of the chemicals used at the dilutions tested. Amine acetate in the concentration used was not found to be toxic. The change in pH due to the use of caustic and sulphuric acids was not sufficient to affect noticeably the test animals. The effect of fuel oil and kerosine alone was not studied, because neither was observed in the wash waters.

Water from effluents of settling areas did not appear to be lethal to the animals tested. This was also true of waters taken directly from the flotation process that had not been diluted with other plant water or mixed with water containing the slimes. (A common method for removal of oil is by entrainment in flocculated suspended material.)

Toxic material used in the flotation process does not appear to be present in the water in amounts sufficient to be lethal to the animals tested.

Tests for Toxic Material in Effluent Water: The laboratory test on minnows indicated that the only likely toxic material used in the processing was the tall oil. Waters from the flotation process, however, were not found to be toxic to the test animals.

Laboratory tests and analyses[9] were made for concentration of tall oil on flotation waters, floated mineral, and sand rejects. The tests showed that if there was any tall oil in the flotation water it was well below the minimum lethal dose of 1 ppm.[10] Tests made on the sand rejects showed that some of the resin soap adhered to it, but the amount found was only a trace. The floated mineral, however, gave tests that indicated that practically all of the converted tall oil was held by the mineral, as would be expected, since the tall oil was used to aid in the floating of the ore.

Table V. Concentration of Flotation Chemicals in Water Used in Tests

	Lb per Gal
Fuel oil	0.000665
Tall oil	0.00016655*
Caustic (20 pct)	0.000133
Sulphuric acid (60° Be)	0.0002
Kerosine	0.00004
Amine acetate (5 pct solution)	0.00001

* Equivalent to 20 ppm.

Waters from all flotation processes and settling areas were found to contain excess soluble calcium that would react with any of the tall oil, or the sodium resinate formed, and precipitate the insoluble calcium soap. Therefore, further assurance was made that no toxic resinate was present in the effluent waters; the insoluble calcium compound being nontoxic to fish,[9] apparently because it is not available for absorption through the gill membrane.

Test on Live Fish: Fish used in the tests conducted in the waters in, or from, the settling areas of phosphate operations were supplied through the courtesy of John F. Dequine, Chief Fisheries Biologist of the Game and Fresh Water Fish Commission of the State of Florida, who consulted and assisted throughout the entire test.

Test Animals: The fish used in the tests were of the families of fresh water fish normally found in the streams and lakes in the State. The fish were seined from a fresh water lake and kept in captivity at the Game and Fresh Water Commission's hatchery near Eagle Lake for approximately one month before the tests were made.

The size and identification of the test animals were recorded, along with the temperature of water, pH, turbidity, and feeding schedule. Fish used were: bass, blue gill, black spotted sun fish, shell cracker, channel cat, black crappie, warmouth, speckled bullhead, golden shiner and sucker.

Fish used in the test were delivered to the site of

the test in the commission's tank truck. The water in the tank was aerated during the time the fish were in transit.

Traps: During the entire test the fish were kept in traps placed in the test waters. The traps were made by covering a cypress wood frame with 18 mesh plastic screening wire. The traps were 6x3x3 ft, entirely closed except for a 10x10 in. hinged opening on one side. The traps were immersed in water to a depth of approximately 3 ft, allowing the side containing the opening to be near the water level.

Conditions and Results of the Tests:* All tests were conducted in the same manner but at different operations. Traps were placed in settling areas, recycling water ditches, and in the effluent at five different operations. A control test was made in a stream containing no phosphate waste water. In all the tests except one, the pH of the water was between 7.2 and 7.4, the temperature at 77° to 80°F, and the turbidity less than 25 ppm. In one test the pH varied between 8.75 and 9.7, the turbidity between 78 and 130 ppm, and the temperature between 74° and 77°F.

* Details of the laboratory tests on minnows and the tests on live fish will be published elsewhere.

In the 96-hr test on live fish, which is that recommended for weak toxicity,[11] there was a 100 pct survival in all the tests and in the control. The fish were left in the traps for an extended period beyond the test time limit and continued to live with but a few fatalities that were due to the effects of cannibalism, parasitism, and other aggressive forces normally following prolonged confinement.

It was observed during an extended period of the test where the pH and turbidity were high, that the fish lived in the cooler water that had been treated with lime, even though the pH was beyond the optimum range for fish[12] and the turbidity high.

The effect of turbidity on the plankton in the rivers was not investigated since the turbidity was shown to be practically constant at points above and below the effluents of the phosphate operations during the time of the test.

During observations of the tests, many minnows and live fish were seen in the water outside the traps. Of the fish seen, those identified were shiner, bass, warmouth and cat.

Conclusions: The waste disposal of the soft pebble phosphate rock industry in Florida during the year 1947 amounted to over six million tons of quartz sand and clay. This material was deposited in large settling areas provided by the individual operators.

Clear effluents from the operations were not found to be toxic and fish lived for 30 days in waters having a turbidity of 80 to 130 ppm.

Provided the wastes from the operations do not cause unreasonable turbidity in the receiving rivers, the wastes from the soft pebble phosphate rock industry are not considered to cause pollution. It is believed that the clear effluent waters from the operations are beneficial to the rivers.

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The author is grateful for the permission obtained from the companies to publish the findings of the study and to the managers and personnel who generously assisted.

The tests on live fish could not have been made without the assistance of John F. Dequine, Chief Biologist of the Game and Fresh Water Fish Commission of Florida, who with his staff supplied the fish for the test and aided and advised throughout the tests.

The data on D.O., B.O.D., and pH were collected by Frank Seely, Assistant Research Engineer. S. L. Besvinick and W. E. Herron, Jr., Graduate Assistants, aided in the collecting of data and in making some of the analyses. The data on flow were obtained from A. O. Patterson, District Engineer, U. S. Geological Survey, Ocala, Fla.

Thanks are due David B. Lee, Chief Sanitary Engineer, Florida State Board of Health, who was responsible for the starting of the study, and to him and his staff for valuable information.

Acknowledgment is given to W. B. Hart, who loaned us his personal copy of "The Evaluation of the Toxicity of Industrial Wastes Chemicals and Other Substances to Fresh-water Fishes," from which valuable information was obtained; Elmer Higgins, Chief Biologist of the U. S. Fish and Wildlife Service, for study of data on fish tests and advice; Kenneth W. Coons, Head, Department of Chemical Engineering, University of Alabama, for information on tall oil toxicity; to Harry Gehm, Technical Advisor, National Council for Stream Pollution, for information on tall oil and tests; to G. R. Grantham, Professor of Sanitary Engineering, for review of the data on D.O. and B.O.D.; and to D. L. Emerson for identification of algae and diatomes and helpful criticisms.

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Sillimanite in the Southeast

by Kefton H. Teague

Attempts to locate domestic supplies of sillimanite have been unsuccessful until recently. This paper describes recent discoveries of sillimanite-bearing schists in the Southeastern States, with emphasis on geology of the deposits, mineral composition, origin, and reserves. Statements concerning possible methods of mining, milling, and utilization of sillimanite are given. Results from refractory tests on a laboratory scale are summarized.

SINCE 1917, when synthetic mullite was first used in spark plug porcelains, there has been a continued search for natural sillimanite. During the recent war this search was intensified, not only for sillimanite but also for any materials which could be used satisfactorily as a substitute for the imported kyanite from India. The Indian massive kyanite does not decrepitate during calcination as does our domestic bladed kyanite, thus a coarse grog can be obtained from it.

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AIME Atlanta Meeting, October 1947.
TP 2879 H. Discussion (2 copies) may be sent to Transactions *AIME before Aug. 31, 1950. Manuscript received Dec. 1, 1947; revision received March 27, 1950.*

Some of the most promising domestic materials suited for high temperatures are limited in quantity. Massive topaz from Chesterfield County, S. C., showed promise of possessing desirable refractory properties; but the action of combined fluorine, liberated during calcination, upon equipment and surroundings, as well as a limited supply of ore and the presence of impurities discouraged its use. Residual lumps and boulders of massive kyanite, similar to the material imported from India, occur in Georgia. This material, like the massive topaz, is of limited quantity. Andalusite from California and dumortierite from Nevada are satisfactory high-temperature refractory materials. Their uses have been restricted to specialized products since the location and character of the deposits are such that large production is impractical.

Sillimanite, like kyanite and andalusite, has the theoretical chemical composition of Al_2SiO_5. It has a hardness of 6 to 7; vitreous, silky to subadamantine luster; specific gravity of 3.2 to 3.3; and is gray to bluish gray in color. Under the binocular microscope, the crystals are transparent. The mineral may occur as dense, fibrous mats (fibrolite) composed of fibrous, sometimes radiating hair-like crystals in schist which are associated with igneous intrusions. Deposits of this type have widespread distribution, but none discovered to date appears to have commercial possibilities. Sillimanite also occurs as bundles of crystals disseminated in biotite schist, as noted in the Hart-Elbert-Madison County, Ga., area and in some of the South Carolina and North Carolina deposits. This type of material has been called prismatic sillimanite by the U. S. Bureau of Mines. Deposits of this variety appear to offer commercial possibilities.

When heated above 1650°C, sillimanite expands about 6.5 pct and is converted into a mixture of mullite ($3Al_2O_3 \cdot SiO_2$) and vitreous silica. This is a stable mixture which has a specific gravity of about 3.15.

General Geology: Sillimanite (fibrolite) is a mineral common to the pre-Cambrian metasediments of the Southeast. It occurs throughout the crystalline schists which lie between the Fall Line on the southeast and the established Paleozoic rocks on the northwest (fig. 1). In addition to the metasediments, this area contains pre-Cambrian igneous

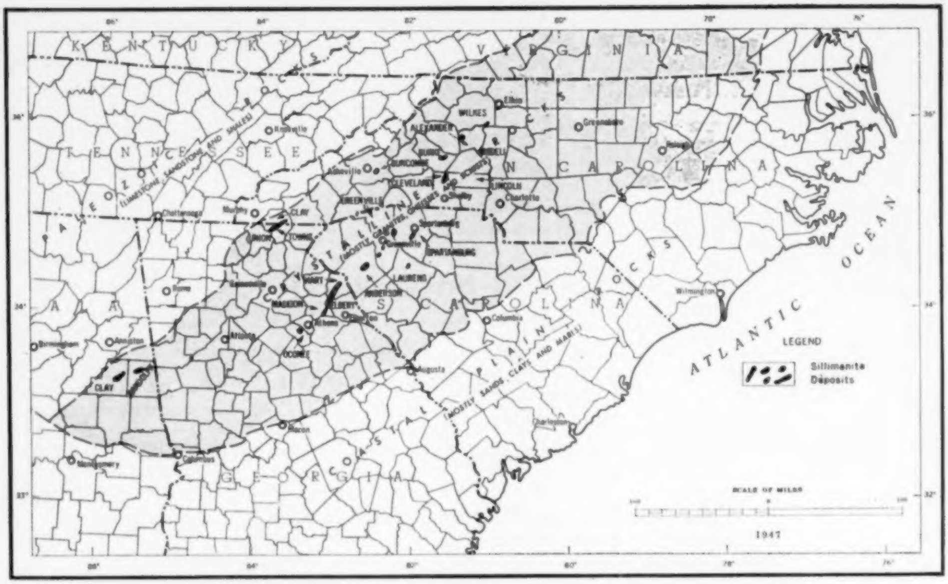

Fig. 1—Distribution of the known sillimanite deposits in the Southeastern States.

gneisses and many granites of probable Paleozoic age. The metasediments, in most cases, appear to be older than the later granites. Schists are intruded by the granites and the effects of granitic injections are exhibited in the schists where coarse recrystallization is superimposed upon the normal grain size at the contacts between the schists and granites or pegmatites.

The widespread sporadic occurrence of sillimanite, as fibrolite, is due undoubtedly to the action of hot solutions from later granites, pegmatites, and quartz veins upon a rock which was originally high in alumina.

In the Davy Mountain area of Georgia and North Carolina, much of the sillimanite is of the fibrolite variety. Other deposits here appear to have been formed from the alteration of kyanite. The fibrolite occurs in a quartz-muscovite schist which contains more or less flake graphite and is associated with bladed kyanite.

Sillimanite, found in the Cliffside-Elkin belt in North Carolina, is mainly of the fibrolite variety; however, at a few places, bundles of crystals weighing up to a pound may occur (fig. 2). This sillimanite-bearing schist occurs in a low southeastward dipping shear zone (20°) which has a rather constant strike of N. 20° E. as contrasted with the regional strike of N. 60° E. The rocks consist mainly of sheared granites, granite gneisses, and quartz-biotite-muscovite schists. The shear zone contains numerous stringers of pegmatite and quartz veins which are postshear in age. It is believed that this sillimanite had its origin in mobile solutions emanating from these small pegmatites and has replaced quartz, biotite, muscovite, kyanite, and garnet.

The better-known deposits of sillimanite in Greenville, Spartanburg, and Anderson Counties, S. C., and in Hart, Elbert, and Madison Counties, Ga., occur in biotite-muscovite schist as roof pendants over younger granite. The sillimanite-bearing schist, as well as the younger granites, has been intruded by later pegmatites and quartz veins. In this area biotite is the dominant type of mica present in the schist; it is older than the sillimanite and occurs as inclusions in the sillimanite crystals. Along contacts with granites and pegmatites, the biotite shows effects of contact metamorphism in that it has been recrystallized into coarser flakes. Sillimanite crystals are larger and more abundant near the schist-granite contact, suggesting that contact metamorphic processes were active in the formation of the sillimanite. Also, near the granite-schist contact, coarse flake graphite occurs locally in granite, probably representing a residue from the assimilated sediment.

All of the sillimanite deposits found to date exhibit more or less secondary sericitization. Inasmuch as sillimanite is considered a high-temperature mineral formed in a deep zone, the later alteration to sericite is ascribed either to hydrothermal solutions which affected the sillimanite in the last stage of igneous injection which produced the sillimanite or to those solutions which came from later granites and pegmatites that were injected into the schist.

Locally, tourmaline occurs in the sillimanite schist, in which case it, like the sillimanite, exhibits similar lineation and relation to enclosing schist minerals. Such occurrences also suggest the high-temperature origin for sillimanite and its direct relation to igneous activity.

Previous Work and Distribution: In 1943, Smith[1] reported sillimanite of possible commercial quantities occurring in South Carolina. Furcron[2] identified sillimanite submitted from Davy Mountain, Towns County, Ga., in the same year. Hudson,[3] in 1943 and 1944, studied numerous outcrops in Georgia

Fig. 2—Bundles of sillimanite crystals disseminated in a biotite-muscovite schist, Burke County, N. C.

Rule 6 in. in length.
(Photo by Charles E. Hunter)

and South Carolina in which he discovered sillimanite. In September 1944, the writer, with A. S. Furcron, discovered a zone of sillimanite schist extending from Madison County northeastward across Elbert County into Hart County, Ga. Charles E. Hunter,[4] TVA, found sillimanite at various places in North Carolina, and in 1945, with Dr. W. A. White of the University of North Carolina, mapped a sillimanite schist zone which extends from Cliffside northeastward across North Carolina to the vicinity of Elkin. In 1944, W. T. McDaniel, Jr.,[5] TVA, reported sillimanite in mica schist from Randolph and Clay Counties, Ala.; however, the extent and richness of the Alabama deposits have not been investigated.

The writer has found, from investigations in Georgia, South Carolina, and North Carolina, that sillimanite in various forms and amounts occurs in almost all of the metamorphosed sedimentary mica schists and gneisses which have been affected by granite intrusions; however, the zones of major concentration are limited. Hudson regarded the sillimanite as occurring in a belt trending from Talbot County, Ga., N. 45° E. for a distance of 200 miles to Spartanburg County, S. C. Also he gives the maximum width of this belt of sillimanite-bearing rock as 15 miles; however, most of the sillimanite in this belt is of the fibrolite variety. If such generalities as to distribution are to be made, then, as has been pointed out previously, all of the metasediments should be included. The writer considers it best to record each deposit as a separate and independent unit.

Exploration and Reserves: In 1945, the U. S. Bureau of Mines prospected by diamond drilling two sillimanite properties in Georgia, one in Hart County and one in Elbert County; and three in Greenville County, S. C. Results of this prospecting have been published by the U. S. Bureau of Mines.[6] Also in 1945, the A. P. Green Fire Brick Co. of Mexico, Mo., prospected by auger and core drilling four properties in Hart and Elbert Counties, Ga. Results from four holes of a total of about 80 are included in the report referred to above.

In August 1945, the Georgia Department of Mines, Mining and Geology and the TVA dug a total of nine pits and trenches on the J. I. Jenkins property in Hart County, Ga. (see northeastern part of aerial photograph, fig. 3). These trenches were placed over a distance of about 1100 ft and a width of about 200 ft. Materials exposed in these openings indicate that about 60 pct of the total is sillimanite-bearing rock. A representative chip sample taken from a trench 176 ft long and representing 109 ft of sillimanite-bearing rock contained 12 pct sillimanite (fig. 4). Another trench 900 ft southwest from the one mentioned above and along the same zone of sillimanite, with a total length of 141 ft, contained a thickness of 85 ft of sillimanite-bearing rock. This rock contains about 10 pct sillimanite. A 100-lb sample taken from a sillimanite-bearing zone about 660 ft northwest of the ridge prospected, but also on the Jenkins property, contained 15.8 pct sillimanite.

The area extensively prospected in Hart County covers about three fourths of an acre. Maximum relief is about 50 ft. This three-quarter acre area is estimated to contain above local drainage about 610,000 tons of sillimanite ore averaging approximately 10 pct sillimanite. It is estimated that about 85,000 tons of ore would be available per 10-ft interval below local drainage in the area described above. Additional ore of similar content on this and nearby properties will increase the above estimate to more than four million tons.

No estimate as to the amount of sillimanite ore is available for any of the South Carolina or North Carolina areas; however, in South Carolina, the area about two miles east of Pelzer in Greenville County appears to offer the greatest promise. In North Carolina, the Prospect Ridge area southeast of Morganton seems to offer the best opportunity in that State.

Anyone interested in prospecting for sillimanite should not rely too heavily upon the abundance of sillimanite float as an indication of a large underlying deposit. The sillimanite ore has much greater resistance to physical and chemical weathering than does the country rock. Frequently, a series of zones of sillimanite not more than a few feet thick will, upon weathering of the country rock, leave numer-

Fig. 3—Aerial view showing distribution of sillimanite outcrops on the Dove, Jenkins, Dickerson, etc., properties. Southwestern Hart County, Ga.

Fig. 4—Specimen showing sillimanite crystals disseminated in biotite schist, Hart County, Ga.

ous fragments of sillimanite in the soil over considerable territory, thus giving the impression that the entire area is underlain by sillimanite-bearing rock. Perhaps the best method of prospecting to overcome this difficulty is by pitting and trenching the deposits.

Mining: In all of the sillimanite-bearing areas examined, the deposits are of such character as to permit open-cut mining. Overburden at none of the deposits is excessive. Some writers have suggested that, where sillimanite does not crop out in sillimanite-bearing zones, it is covered by a thick mantle of soil. Actually, this condition is caused by the weathering of nonsillimanite-bearing rock; thus, it is useless to expect to find deposits of sillimanite concealed by deep residual soil. The sillimanite-bearing rocks generally form a definite ridge or hill which rises as much as 30 ft above the surrounding country; but only in the North Carolina deposits is there sufficient relief to permit the development of high quarry faces. In Georgia and South Carolina it would appear that several benches at about 20-ft intervals would be more practicable than one high face.

Any mining of the sillimanite deposits, from necessity, would require more or less selective mining. Granite and pegmatite intrusions in the deposits that exceed 4 ft in thickness probably could be eliminated in quarry, but the *lit par lit* character of granite and sillimanite will necessitate milling some barren rock.

Milling: Beneficiation tests of the sillimanite ore on a pilot plant scale, using a flotation process, have been conducted successfully by the U.S. Bureau of Mines Southern Experiment Station Laboratory at Tuscaloosa, Ala.,[8] and by the TVA Chemical Engineering Laboratory at Muscle Shoals, Ala. In addition to flotation, the Bureau employed tabling prior to flotation in an attempt to secure a coarser concentrate.

In general, the following processes were involved in concentrating the sillimanite ore: The ore was wet ground to —28-mesh and froth-floated. The flotation concentrate was dried and further processed by passing it over a magnetic separator. A large amount of the iron oxide present in the concentrate was removed by magnetic separation. In one case, the iron oxide content was reduced from 11.7 pct to only 1.1 pct, and acid leaching brought this to 0.5 pct. The surface iron oxide is that part removed by acid treatment. It is probable that finer grinding would increase the amount of impurities removed. The acid-washed concentrate shows no iron oxide spots under the binocular microscope; thus, the remaining iron in the acid-treated concentrate probably occurs in small particles of biotite which were not liberated during grinding. Table I gives the screen analyses and table II the chemical analyses of nonmagnetic Georgia and South Carolina sillimanite.

The iron content of the untreated concentrate is not great enough to cause any difficulty in its use in refractories; however, acid leaching might be required for specialized products. All ores treated thus far are taken from near the surface and therefore are highly oxidized. Secondary ferric oxide should not occur at or below water level.

Laboratory Results: No attempt is made to cover completely the results obtained from laboratory research upon the sillimanite concentrates because that phase of the problem is considered beyond the scope of this paper. It is sufficient to point out that laboratory results obtained upon the ceramic properties of sillimanite indicate that products can be made from sillimanite having original linear shrinkage which ranges from 0 to 0.2 pct when fired to 1600°C. The bricks were reheated 5 hr to 1600°C and met both the reheat specifications of the A.S.T.M. and those of the U. S. Navy for superduty refractories.

The results of the high-temperature load tests indicate that sillimanite brick has excellent load-carrying capacity at high temperatures and, in the alumina-silica class, is probably exceeded only by electrocast corundum-mullite.

Inversion of the sillimanite to mullite proceeds rapidly at 1650°C with a volume expansion of about 6.7 pct and a linear expansion of 1.2 pct. This change may occur at a lower temperature with an increase in time of heating. The temperature of inversion is above that usually encountered in refractory service; therefore, the small expansion at such high temperatures suggests good rigidity and resistance, whereas most refractories show softening and weakening under load.

Possible Uses: In the past, there has been no dependable source of sillimanite; therefore, there are

Table I. Screen Analyses of Nonmagnetic Georgia and South Carolina Sillimanite, Pct

Coarser Than Mesh No.	Georgia	South Carolina
28	0.2	0.1
35	11.0	2.3
48	30.5	12.0
65	50.2	32.3
100	71.1	58.1
150	84.7	76.5
200	94.2	89.8

Table II. Chemical Analyses of Nonmagnetic Sillimanite Concentrates, Pct[a]

	Georgia	South Carolina
SiO_2	39.69	37.59
Al_2O_3	57.95	59.75
TiO_2	0.20	0.24
Fe_2O_3	0.99	1.20
Total	98.83	98.78

[a] Analyses by R. H. Stacy, Southern Experiment Station, and P. G. Cotter, Electrotechnical Laboratory, U. S. Bureau of Mines.

no established uses for it. At present, a number of high-grade alumina products are made from several sources, including the crystalline corundum produced in the electric furnace from bauxite, corundum-mullite electrocast refractories made from a mixture of bauxite and fire clay, mullite refractories made from domestic and Indian kyanite, and small amounts made from western domestic andalusite, as well as a little made from South Carolina topaz.

Some of the potential uses for sillimanite are: porcelain for spark plugs, high aluminous refractory bricks (fig. 5), crucibles, saggers of all types, boiler linings, high-temperature cements, linings for indirect-arc and heat-treating furnaces, pyrometer tubes, glass tank blocks, etc.

Conclusions: The annual consumption of minerals in the sillimanite group can be estimated only roughly, as many of the producers of these minerals are also consumers and production figures are not available. However, it is believed that the preparation of a high quality concentrate would permit marketing of 15,000 to 20,000 tons of sillimanite per year. Certain outstanding conclusions which have been established to date may be briefly summarized as follows:

1. All of the known domestic sillimanite occurs as disseminated crystals in various types of metasediments.

2. Known deposits that appear to offer the best chances for development listed in the order of their importance are: (*a*) Hart-Elbert-Madison County, Ga., belt; (*b*) Anderson-Spartanburg-Greenville County, S. C., belt; and (*c*) Cliffside-Elkin, N. C., belt. Abundance and size of sillimanite crystals in large samples concentrated from each of these areas substantiate this conclusion.

3. The area in southwestern Hart County contains several million tons of sillimanite ore which range from 10 to 12 pct in sillimanite content.

4. Future intensive search for sillimanite, no doubt, will result in the discovery of deposits as good as, and perhaps better than, any discovered to date.

Fig. 5—Sillimanite ore on left, concentrate in center, and 8-in. brick made from sillimanite concentrate on right.

(Photo by P. D. Rogers)

5. The sillimanite ore is readily concentrated by froth flotation.

6. Laboratory research upon bricks made from sillimanite indicates that it makes a superior refractory.

7. Possible uses for sillimanite are quite numerous, suggesting that a considerable tonnage could be utilized by various industries.

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Correction

In the March 1950 issue: TP 2815 B. *Radiotracer Studies on the Interaction of Dithiophosphate with Galena* by G. L. Simard, J. Chupak, and D. J. Salley. p. 359, abstract, line 4, reversible should read irreversible. p. 361, table II, line 3, 6 (leached) should read 5 (leached); fig. 4, ordinate, mol/gram should read mol/cm^2. p. 363, table VII, first subtitle, Galena No. 2 should read Galena No. 2 (unleached), p. 364, third paragraph, line 6, dithiophosphate should read dithiophosphate solely; 4th paragraph, line 17, reference 10 should read reference 11, and reference 7 should read reference 8; References, No. 7, *A. Electrochem.* should read *Z. Electrochem.*

Some Recent Investigations with the Dutch State Mines Cyclone Separator on Fine Coal Slurries

by S. A. Falconer

This paper deals with the practical application of the Dutch State Mines cyclone separator for fine-coal cleaning. The more important operating variables are discussed, and results of a number of continuous-scale tests on various fine coals with a 6-in. cyclone separator are given. Descriptions of the Cyanamid Pilot Plant and the 50 tph Cyclone Separator Plant at the Emma Washery in Holland are included.

TODAY, as never before, the coal producers of this country are faced with the necessity for obtaining maximum yield of marketable coal of all sizes down to and including the finest. Particular interest is being displayed in a more effective means of recovering the finer sizes which in the past so often have been discarded to waste or treated by inadequate equipment. The reasons for this interest are easily understood. Rising mining costs have resulted in the increased use of mechanized equipment underground for full seam mining. This, in turn, means more refuse in the run-of-mine and also more fines in the feed going to the cleaning plant. Stringent antistream pollution laws now make it necessary at least to impound the fines, and usually it is a paying proposition to recover the coal from these fines before sending them to the storage area. Finally, the market and price of the finer sizes has increased, but at the same time specifications have tightened and the demand is for higher grade products.

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During the past four years a great deal of publicity has been given to this new process and apparatus for treating fine sizes of ores as well as coal. Excellent discussions of the apparatus itself and the theoretical aspects of the basic operating principles involved in its operation have been presented by M. G. Driessen,[1-3] M. R. Geer and H. F. Yancey,[4,5] J. W. Hyer[6] and more recently by D. A. Dahlstrom[8] as well as others.[7, 9-11] In view of this, it has been decided to include in the present paper only a brief description of the cyclone separator and its operating principles. This paper deals primarily with some of the more practical commercial aspects of the process and equipment required for its operation; the variables in the operation of the cyclone, their effect and means for control; and the results obtained with a 6-in. semicommercial size separator on a variety of fine coals, bituminous and anthracite, using finely ground magnetite for the separating medium solids. A description is included of the commercial-size cyclone separator pilot plant installed by the Dutch State Mines at its Emma mine in Holland, where finely ground slate is utilized as medium solids.

Field of Application: The Dutch State Mines cyclone separator operates most efficiently on ores and coal in the size range of ⅜ in. to about 48 mesh. On some types of feed, effective separation can be made on sizes as small as 100 mesh, but up to the present, this may be considered exceptional.

Depending upon the type of medium used, the specific gravities of separation can be varied within wide limits, up to as high as 2.70, if magnetite is used as medium.

Early Development: The development of the Dutch State Mines cyclone as a separator, or cleaner, was the outgrowth of early experimental work by Driessen[1] and others in Holland, just prior to World War II, in the course of which was discovered the effectiveness of the cyclone in reclaiming and thickening the dense medium used in the "Loess" process of

coal cleaning. These early investigations with the cyclone eventually lead to the further discovery that under certain controlled conditions, using correct proportions of finely ground media of appropriate specific gravity, the centrifugal and centripetal forces in a properly designed cyclone are capable of effecting very efficient separations of fine size coal from refuse on the basis of their specific gravity differences.

Of the efficiency of a true sink-and-float method in separating coal from refuse, there can be no question. The industry has been seeking a way to make accurate separation at low cost of all sizes at a predetermined point on the washability curve. Sink-and-float processes, in which gravity is the separating force, employing finely ground suspensions of solids of suitably high specific gravity, approach very closely the properties of a true heavy liquid. Today there are about 80 coal cleaning plants in this country and in Europe using these very efficient processes for treating sizes coarser than about 10 mesh. Unfortunately, these processes are not readily adapted to the treatment of finer sizes, those below about 10 mesh, because of the much longer time required for separation of the particles in a dense medium (or even in a true heavy liquid). Below 10 mesh, the size of installation and cost of coal cleaning plants employing sink-and-float principles to effect separations under static conditions increase in proportion with increasing fineness of the feed. However, if means are supplied to increase the velocity of fall of the heavier fine particles in the separatory fluid, it becomes commercially practical to make separations of these finer sizes on the basis of their specific gravity differences. The Dutch State Mines cyclone separator most effectively furnishes this means and makes possible sharp, efficient separations at particle sizes as small as about 48 mesh. The medium solids used in making the separation may be autogenous (inherent in the material to be separated); or exogenous (extraneous material not inherently present in the feed to be treated).

Construction and Operating Principles of the Cyclone Separator: The cyclone separator or "washer" is a simple centrifugal type, utilizing no mechanical means to remove the float-and-sink products. The essential details of construction of a typical separator are shown in fig. 1.

The material to be treated is fed into a suspension consisting of very fine medium solids and water (the specific gravity of which can be considerably lower than the required separating gravity), and the mixture is introduced tangentially under pressure, usually supplied by means of a centrifugal pump, through the feed inlet (*1*) into the short cylindrical section (*2*). The latter also carries the central "vortex finder" (*3*) which guides the upwardly flowing stream of lighter gravity particles or "float" to the discharge outlet (*6*) and prevents short-circuiting of the incoming feed within the cyclone. Separation is effected in the cone-shaped part (*4*) by the action of: (*a*) centrifugal forces which draw the heavier gravity particles to the wall of the cone and eventually discharge them through the bottom or "apex" orifice (*5*); and (*b*) centripetal forces which sweep the lighter gravity particles toward the central vortex where they leave the cone through the "vortex finder" (*3*).

In commenting on certain theoretical considerations involved in the working principles of the cyclone separator, Driessen[2] offers the explanation that:

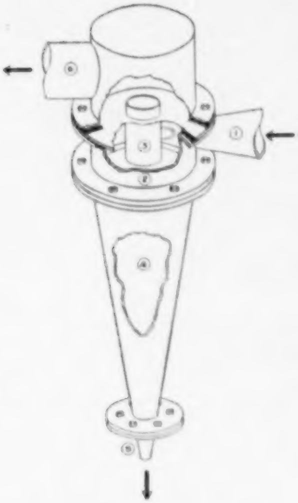

Fig. 1—Details of construction of a typical cyclone separator.

In the Cyclone a state of equilibrium appears to exist between the centrifugal force working on the small suspension particles and the flow of the liquid, which acts in the opposite direction. The suspension particles, which are introduced into the Cyclone together with the raw fine coal, are forced towards the cone wall and move down toward the apex. Here a part leaves the Cyclone and another part rises in the central vortex and either leaves the Cyclone at the top or is again forced towards the walls. . . . part of the suspension particles are circulating in the Cyclone, so that it is possible that the concentration, and therefore the specific gravity of the suspension is higher in the Cyclone than the specific gravity at the inlet and outlet . . . (vortex finder). The small suspension particles introduced into the Cyclone, together with the raw coal, form a block for coal particles, whereas the shale particles due to their higher density can readily migrate through the bed.

Operating Variables: Although the cyclone separator is fundamentally an extremely simple piece of apparatus, there are a number of variables involved in its operation which influence its capacity and the efficiency of separation. Of these the following have been found to be the most important: (1) diameter of cyclone, and steepness of the conical section; (2) type and fineness of the medium solids used for separation; (3) specific gravity of the medium suspension and solids; (4) size of orifice at apex (sink) discharge; (5) pressure used in introducing feed and medium to the separator; (6) ratio of medium to raw coal feed; (7) tonnage rate and variation in proportion of coal and refuse; (8) diameter of feed inlet; (9) diameter and position of "vortex finder" (outlet for float, or coal); (10) particle size of raw coal feed; and (11) viscosity.

Testing

Cyclone Separator Installations in Cyanamid's Pilot Plant: Following the appointment of American Cyanamid Co. as exclusive technical and sales representatives in the United States for the Dutch State Mines cyclone separator in 1946, apparatus was installed in the pilot plant in Stamford, Conn., for research work and testing of all types of ores and coals on a batch scale or a continuous, semicommercial scale.

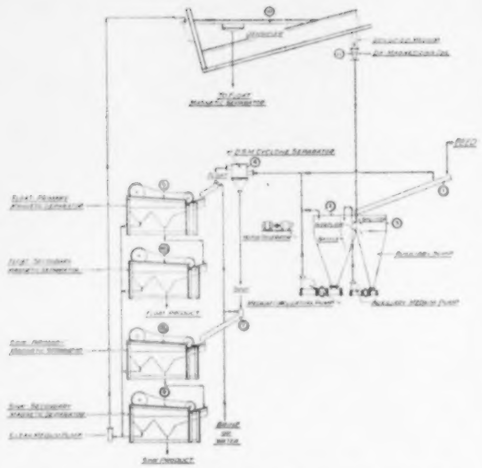

Fig. 2—Dutch State Mines cyclone flowsheet for double cleaning circuit with primary and secondary magnetic separators.

In this pilot plant, a 6-in. cyclone separator is used for continuous scale testing of ores and coal at feed rates up to about 4 tph of a size range of —¼ in. x 0. For small-scale batch testing a 3-in. cyclone separator is available. This latter apparatus is capable of handling feeds up to about 10 mesh.

The 6-in. Cyclone Separator Plant: In the operation of this 6-in. cyclone separator plant, the material to be tested is either stored in a stockpile just outside the pilot plant or in the small bin inside it. If the feed is known to contain oversize material, it is necessary to remove it before introducing this feed to the cyclone separator. Therefore, the first stage of the operation usually consists of feeding the material either from the stockpile by means of a set of portable conveyors, or from the bin onto a 2x8 ft Tyler Tyrock screen. The oversize from this screen, after sampling, is removed to waste or to storage in case some separate form of treatment is desired.

The undersize of this screen is sluiced by means of medium supplied through a by-pass pipeline into a 4-in. Wemco pump sump. The medium used for this purpose is the overflow from the 4-in. pump sump which flows into the hopper of a 2-in. Wemco pump used to control the level in the 4-in. pump sump. In addition to the overflow from the 4-in. pump sump, the 2-in. pump sump also receives the densified return medium plus the water that is added to dilute the densified medium to the required specific gravity for the cyclone separator feed.

The 4-in. Wemco pump referred to above delivers the —¼-in. feed plus the required volume of medium to the cyclone separator. This pump line is equipped with a by-pass so that the required volume of feed and the correct pressure may be maintained in the cyclone separator.

The 6-in. cyclone separator is installed a short distance above a longitudinally divided 2x8-ft Allis-Chalmers Lohead vibrating screen equipped with 8 or 10-mesh woven-wire cloth. The apex discharge (sink) and the vortex discharge (float) are discharged separately onto the divided screen. The oversize products travel along the screen, through which most of the medium and undersize float or sink is removed by straight drainage. The remaining adhering medium and fine float and fine sink are removed by means of water sprays located near the discharge end of the screens.

A portion of the medium and the separated products which are removed by drainage through the screen is returned to the sumps shown in fig. 2.

The undersize from the section of the screen handling the apex discharge, or sink, together with most of the medium that has drained through the sink side of the screen is delivered by a 2-in. Wemco pump to the first of two 12-in. Dings-Crockett S-F type magnetic separators, which are operated in series. Practically all of the magnetic medium contained in the pulp is recovered in the first magnetic separator; the second magnetic separator acts principally as a scavenger to remove the last traces of medium from the sink product. While tailing from the second magnetic separator is being pumped to waste, timed samples are cut accurately for analyses and tonnage estimating purposes.

The float washings and the adhering portion of the medium draining through the screen handling the float product are treated in a manner similar to that described above for the sink drainage and washings.

The combined magnetic material recovered from the float and the sink magnetic separators is delivered to the sump of a 2-in. Wilfley pump which delivers the medium to a 24-in. Akins Densifier. Sometimes, instead of the densifier, a 6-ft thickener and a 2-in. Dorrco type VM diaphragm pump are used. The returned medium, whether from the densifier or the thickener, passes through a 3-in. ac demagnetizing coil before returning to the cyclone feed circuit.

The above-mentioned equipment and auxiliary apparatus are installed in such a manner as to provide maximum flexibility. The cyclone separator is built so that its various parts may be interchanged readily to provide larger or smaller openings of feed, apex, and vortex; or to provide for greater or less slope of the conical section of the apparatus. The above-mentioned description applies both to the flowsheet used in the pilot plant, when screens are employed ahead of the cyclone separator, and to treat the separated products. However, on some types of materials, it may not be necessary to feed the screens ahead of the cyclone separator and there may not be a sufficient amount of +10-mesh sizes in the feed to warrant passing the separated products over drainage and washing screens. In such cases, the flowsheet shown in fig. 2 is employed. Referring to fig. 2, it will be noted that the feed, together with medium, is sluiced down the launder (*1*) into a feed sump (*2*) from which it is fed by the 4-in. pump to the cyclone separator (*4*). The medium and feed in the sump (*2*) are maintained at a constant level by means of the sump (*3*) and the 2-in. auxiliary pump, as shown.

It will be noted that the vortex discharge of the cyclone separator flows directly by gravity to the magnetic separator (*5*) where most of the medium is recovered for re-use. The tailings from the magnetic separator (*5*) flow by gravity to the secondary magnetic separator (*6*). The nonmagnetics of the latter form the finished float product, while the small additional amount of medium that may be recovered in this secondary separator joins the magnetic medium from the primary separator (*5*). The apex discharge from the cyclone separator (*4*) flows down a launder (*7*) to the primary magnetic sepa-

rator (*8*). Normally, water is used to dilute this thick apex discharge in order to assist its flow and the separation in the magnetic separator (*8*). However, in the treatment of potash ores, saturated brine would be used instead of ordinary water at this point. As in the case of the float recovery circuit, the tailing from magnetic separator (*8*) flows by gravity to the secondary magnetic separator (*9*) where the last traces of magnetic medium are removed from the finished sink product. The magnetic material recovered by this secondary separator joins magnetic material recovered from the primary magnetic separator (*8*).

All of the recovered medium from magnetic separators *5*, *6*, *8*, and *9* are joined and pumped to a densifier (*10*). The overflow from the latter is substantially free of magnetic solids but to avoid any possible loss at this point, this overflow is directed back to the primary magnetic separator (*5*). The thickened solids from densifier (*10*) are discharged through a tube surrounded by an ac demagnetizing coil and delivered back to pump hopper (*3*) or (*2*). This densified material is, of course, diluted with whatever amount of water or brine is needed to bring the medium solids to the required density for feeding into the cyclone separator.

The 3-in. Cyclone Separator for Batch Testing: The 3-in. cyclone separator and auxiliary apparatus for conducting batch tests are shown in fig. 3. A hopper is provided to hold the sample of the material to be tested together with a desired proportion of fluid medium. This conical hopper is connected to the 2-in. Wemco pump which is used to introduce the feed into the cyclone separator. A by-pass on the pump line permits recirculation of the feed and medium directly back to the hopper when desired.

In operation, the feed and medium, after suitable mixing, are introduced into the cyclone separator at whatever pressure desired, the pressure being regulated by the by-pass line. The vortex overflow and the apex discharge from the 3-in. cyclone separator flow back into the hopper. Timed samples of both of these discharges are caught during the running of the test.

With this setup, it is possible to conduct a great number of tests on any given material with relative

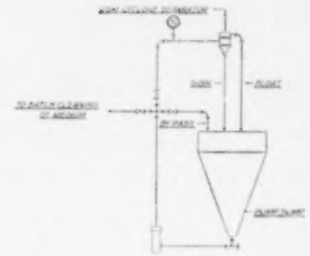

Fig. 3—Dutch State Mines 3-in. cyclone separator.

ease and rapidity. For practical reasons, however, only a few tests can be made with any single charge of a material since it is undesirable to recirculate the separated products for any extended time because repeated passage through the pump degrades the feed.

As previously mentioned, the size of this cyclone separator precludes the treatment of feeds coarser than about 10 mesh. However, this small apparatus does perform a very useful function in that it permits making a large number of tests on a relatively small amount of material. The results of these batch tests provide a reliable guide as to what separations might be expected with larger commercial-size cyclone separators. If results with the 3-in. cyclone are favorable, further testing on a continuous scale with the 6-in. cyclone separator can be justified. When desired, the 6-in. cyclone separator also can be used for batch testing by using a flow scheme similar to that employed with the 3-in. cyclone.

Results of Cyclone Separator Testing of Samples of Bituminous and Anthracite Coals: The following are some typical examples of results which can be expected with the Dutch State Mines cyclone separator on bituminous and anthracite fines.

It will be observed that the separations obtained in the various examples reported were made under differing sets of conditions. In each case, the conditions reported are those which were found to be best suited for the particular type of material tested.

Example No. 1

Bituminous coal fines from current mining, Pittsburgh seam.
Size range tested, ¼ in. x 48 mesh.
Analysis of raw coal feed.

Size	Pct Weight	Pct Ash	Pct Sulphur
¼ in. x 4 mesh	3.5	11.14	1.45
4x14 mesh	63.4	14.66	1.51
14x28 mesh	18.3	12.90	1.49
28x48 mesh	11.2	14.38	1.74
48x100 mesh	1.9	17.86	2.03
100x200 mesh	1.0	27.20	4.54
—200 mesh	0.7	36.05	2.60

Washability Studies, Sink-and-Float Tests, Raw Coal

Size Range	Float 1.30			Sink 1.30 Float 1.35			Sink 1.35 Float 1.40			Sink 1.40 Float 1.45		
	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S
¼ in. x 14 mesh	64.5	4.91	0.94	15.6	7.50	1.60	4.6	11.57	2.86	2.7	16.33	3.78
14x48 mesh	59.2	3.02	0.97	21.5	7.17	1.44	3.8	11.82	2.48	2.6	15.73	3.09
48 mesh x 0	20.7	4.00	0.98	27.9	8.66	1.26	13.7	14.16	1.62	5.2	17.11	2.20
Total ¼ in. x 0	61.4	4.35	0.95	17.8	7.01	1.32	4.7	11.9	2.63	2.7	16.3	3.50

Size Range	Sink 1.45 Float 1.55			Sink 1.55		
	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S
¼ in. x 14 mesh	1.5	23.55	4.27	11.1	73.67	2.40
14x48 mesh	1.8	21.93	3.85	11.1	67.79	3.67
48 mesh x 0	2.1	19.35	2.95	30.4	53.19	6.22
Total ¼ in. x 0	1.6	22.8	4.05	11.8	70.2	3.02

Cumulative Float on 1.55 sp gr, 88.2 pct weight at 6.00 pct ash, 1.27 pct sulphur.
Sink in 1.55 sp gr, 11.8 pct weight at 70.2 pct ash, 3.02 pct sulphur.

Operating details of test at 1.55 sp gr separation.
6 in. Cyclone, 15 in. cylindrical section, 3¾ in. conical section.
Pressure, 20 psi.
Orifice feed inlet, 3 in. reduced to 1 in.
Orifice vortex (top outlet), 2 in.
Orifice apex (bottom outlet), 15/16 in.
Feed rate, 1⅛ tph.
Medium used, "B" Magnetite (—100-mesh, 75 pct—325-mesh).
Specific gravities, medium, feed, 1.185; overflow, 1.14; underflow, 2.15.

Results, Clean Coal, 88.92 pct weight recovery, 5.81 pct ash, 1.34 pct sulphur.

Size Range	Float 1.50			Sink 1.50 Float 1.55			Sink 1.55		
	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S	Pct Wt.	Pct Ash	Pct S
+10 mesh, 66.1 pct	99.37	5.10	1.27	0.36	25.91	3.61	0.27	33.45	3.10
—10 mesh, 33.9 pct	95.50	5.34	1.40	1.73	23.82	3.49	2.77	52.05	3.60
Total ¼ in. x 0	98.05	5.16	1.30	0.83	24.10	3.50	1.12	49.10	3.58
Refuse, 11.08 pct weight recovery, 69.84 pct ash, 3.82 pct sulphur.									
+10 mesh, 52.6 pct	2.69	12.88	2.63	3.24	27.03	3.88	94.07	75.22	2.55
—10 mesh, 47.4 pct	2.67	12.50	2.52	2.30	20.12	3.00	95.03	71.37	5.29
Total ¼ in. x 0	2.68	12.70	2.58	2.79	24.40	3.54	94.53	72.80	3.85

Efficiency of Separation

	Pct Weight Yield Coal at 1.55 Sp Gr	Pct Ash	Pct S	Pct 1.55 Sp Gr Sink in Coal	Pct 1.55 Sp Gr Float in Refuse
Theoretical	88.2	6.00	1.27	Nil.	Nil.
Cyclone separation	88.92	5.81	1.34	1.12	5.47

Example No. 2

Anthracite culm bank fines.
Size range of feed, 5/16 in. x 0.
Analysis of raw coal feed.

Size	Pct Weight		Pct Ash	
	Ind.	Cum.	Ind.	Cum.
+5/16 in.	0.4	0.4	54.15	54.15
—5/16x3/16 in.	1.5	1.9	57.60	56.87
—3/16x3/32 in.	5.1	7.0	40.30	44.80
—3/32x1/16 in.	8.4	15.4	34.15	38.99
—1/16x3/64 in.	13.7	29.1	33.30	36.31
—3/64x1/32 in.	18.6	47.7	30.80	34.16
—1/32 in. x 35 mesh	17.4	65.1	35.35	34.48
—35x48 mesh	13.5	78.6	35.65	34.68
—48x65 mesh	8.8	87.4	44.45	35.66
—65x100 mesh	5.1	92.5	40.47	35.93
—100 mesh	7.5	100.0	46.45	36.72

Operating Conditions

6 in. cyclone 60° cone.
Pressure, 20 psi.
Feed inlet orifice, 1⅛ in.
Orifice vortex (top outlet), 1⅛ in.
Orifice apex (bottom outlet), 1.2 in.
Specific gravity feed, 1.57; overflow, 1.29; underflow, 2.21.

Size Range	Screen Oversize Coal				Screen Undersize Coal			
	Pct Weight		Pct Ash		Pct Weight		Pct Ash	
Clean Coal	Ind.	Cum.	Ind.	Cum.	Ind.	Cum.	Ind.	Cum.
+5/16 in.	1.7	1.7	15.05	15.05				
—5/16x3/16 in.	8.4	10.1	12.10	12.60				
—3/16x3/32 in.	39.0	49.1	9.10	9.82				
—3/32x1/16 in.	39.8	88.9	9.05	9.47	2.9	2.9	11.32	11.32
—1/16x3/64 in.	8.4	97.3	9.70	9.49	11.9	14.8	11.25	11.26
—3/64x1/32 in.	1.9	99.2	10.70	9.52	19.5	34.3	10.83	11.02
—1/32 in. x 35 mesh	0.4	99.6	11.35	9.52	20.1	54.4	12.16	11.44
—35x48 mesh	0.2	99.8	16.30	9.54	16.5	70.9	13.84	12.00
—48x65 mesh	0.2	100.0	9.40	9.54	11.6	82.5	15.64	12.51
—65x100 mesh					7.2	89.7	19.10	13.04
—100 mesh					10.3	100.0	34.69	15.27

Refuse

+5/16 in.	1.9	1.9	70.94	70.94				
—5/16x3/16 in.	9.7	11.6	75.13	74.44				
—3/16x3/32 in.	37.5	49.1	66.15	68.11				
—3/32x1/16 in.	36.7	85.8	62.86	65.86	5.1	5.1	61.8	61.8
—1/16x3/64 in.	10.0	95.8	65.62	65.84	17.6	22.7	60.6	60.87
—3/64x1/32 in.	3.2	99.0	66.12	65.85	25.3	48.0	59.85	60.33
—1/32 in. x 35 mesh	0.6	99.6	71.18	65.88	21.0	69.0	68.00	62.67
—35x48 mesh	0.2	99.8	64.64	65.88	13.7	82.7	67.50	63.47
—48x65 mesh	0.2	100.0	59.02	65.86	7.8	90.5	68.90	63.93
—65x100 mesh					4.6	95.1	68.45	64.15
—100 mesh					4.9	100.0	69.00	64.42

Example No. 3

Anthracite silt bank.
Size of feed, —3/16 in. x 0.
Analysis raw coal feed.

Screen Analysis, Raw Coal Feed

Mesh	Pct Wt.	Pct Wt. Cumulative	Pct Ash	Pct Ash Cumulative
—3/16 in +20	47.41	47.41	37.14	
—20 +35	14.28	61.69	34.76	
—35 +48	9.16	70.85		
—48 +65	8.46	79.31	34.33	
—65 +100	5.68	84.99	38.62	36.80
—100 +150	3.24	88.23	34.80	
—150 +200	1.88	90.11	39.15	
—200	9.89	9.89	64.25	57.24
Total	100.00	100.00	38.69	38.69

Operating Details and Results of Separation

Type of cone, 20°.
Pressure, 20 psi.
Orifice feed inlet, 1⅛ in.
Orifice vortex (top outlet), 1½ in.
Orifice apex (bottom outlet), 1.2 in.
Feed rate, 2½ tph.
Medium used, Magnetite "B".
Specific gravities: feed, 1.69; vortex, 1.44; apex, 2.24.

Products	Pct Wt. of Product	Pct Weight of Raw Feed	Pct Ash	
			Ind.	Cum.
Raw coal feed		100.0	38.94	
Clean coal (full size range)		68.28	20.81	
Refuse		31.72	77.97	
Clean Coal				
(screen)				
+20 mesh (o'size)		33.72	12.98	12.98
—20 mesh x 0	100.0	34.56	28.44	20.81
—20x35 mesh	19.73	6.82	12.27	12.88
—35x48 mesh	15.47	5.35	13.60	12.95
—48x65 mesh	15.86	5.48	15.80	13.25
—65x100 mesh	11.80	4.08	19.73	13.73
—100x150 mesh	7.34	2.61	24.64	14.22
—150x200 mesh	[illegible].64	1.60	33.23	14.73
—200 mesh	24.96	8.62	62.88	20.81

Clean coal with —200-mesh fines removed, 59.66 pct weight recovery in product analyzing 14.73 pct ash. With the —100 mesh sizes removed, the weight recovery of coal would be reduced to 55.45 pct but the ash content would be only 13.73 pct.

Refuse

(screen)				
+20 mesh (o'size)		13.69	78.18	78.18
—20 mesh x 0	100.0	18.03	77.82	77.97
—20x35 mesh	41.36	7.46	77.97	78.10
—35x48 mesh	21.13	3.81	78.75	78.20
—48x65 mesh	16.54	2.98	78.73	78.26
—65x100 mesh	8.88	1.60	78.12	78.25
—100x150 mesh	3.52	0.63	76.29	78.21
—150x200 mesh	1.53	0.28	73.30	78.17
—200 mesh	7.04	1.27	73.33	77.97

Efficiency of Separation Based on Sink-Float Tests on Recovered Coal Sizes

	Pct Weight Recovery		Pct Ash Clean Coal		Sp Gr Separation	Pct Recovery on Total Feed Coal	
	Theory	Actual	Theory	Actual		Theory	Actual
Size Fraction							
+20 mesh	62.39	61.89	12.20	12.24	1.88		13.48
—20x48	67.27	65.72	11.26	12.02	1.94		29.23
—48x65	72.97	70.11	14.52	16.40	2.06		6.92
—65x100	73.76	72.79	21.37	25.42	2.09		7.58
—100	?	82.34	?	53.45	?		
Total +100	57.57	57.21	12.45	14.38	1.95[a]	57.57	57.21
Calc. feed				38.69			

[a] Weighted average.

Example No. 4

Anthracite silt bank material.
Size range of feed, —3/32 in. x 100 mesh.

Analysis Raw Coal Feed

Mesh	Pct Weight Ind.	Pct Weight Cum.	Pct Ash Ind.	Pct Ash Cum.
+3/32 in.	4.22	4.22	22.8	22.8
—3/32x3/64 in.	46.55	50.77	25.7	25.5
—3/64 in.x28 mesh	12.21	62.98	28.6	26.1
—28x35 mesh	27.09	90.07	35.1	28.8
—35x48 mesh	4.77	94.84	35.3	29.1
—48x60 mesh	1.24	96.08	34.4	29.2
—60x100 mesh	1.76	97.84	37.3	29.3
—100x150 mesh	0.50	98.34	38.4	29.4
—150x200 mesh	0.34	98.68	40.0	29.4
—200 mesh	1.32	100.00	55.8	29.8

Sink and Float Washability Tests on Raw Coal Feed

Specific Gravity		Float				Sink	
		Pct Weight		Pct Ash			
Sink	Float	Ind.	Cum.	Ind.	Cum.	Pct Wt. Cum.	Pct Ash Cum.
	1.60	42.12	42.12	5.2	5.2		
1.60	1.70	21.40	63.52	12.0	7.5	57.88	47.5
1.70	1.80	6.20	69.72	23.0	8.9	36.48	68.3
1.80	1.90	2.72	72.44	33.5	9.8	30.28	77.6
1.90	2.00	2.20	74.64	42.5	10.8	27.56	82.0
2.00		25.36		85.4	29.8	25.36	85.4

Cyclone Separator Tests, Operating Details

Separator, 6 in. cone 60°.
Orifice feed inlet, $1\frac{1}{3}$ in.
Orifice vortex (top outlet), $1\frac{1}{2}$ in.
Orifice apex (bottom outlet), 1.2 in.
Pressure, 20 psi.
Feed rate, $1\frac{1}{3}$ tph.
Medium used, Magnetite.

Pct Yield and Ash of Products

Test No.	Sp Gr Medium Fed to Separator	Pct Weight Recoveries						Pct Ash in Products					
		Coal			Refuse			Coal			Refuse		
		+10 Mesh	—10 Mesh	Total	+10 Mesh	—10 Mesh	Total	+10 Mesh	—10 Mesh	Total	+10 Mesh	—10 Mesh	Total
1	1.54	23.61	49.96	73.57	7.47	18.96	26.43	8.5	10.3	9.7	85.1	80.7	81.94
2	1.58	23.21	52.93	76.14	8.25	15.61	23.86	9.2	12.6	11.6	85.3	83.8	84.32
3	1.63	32.31	47.62	79.93	4.11	15.96	20.07	9.7	13.8	12.1	80.5	85.6	84.56

Pct Coal and Refuse in Final Products

Test No.	Approx. Separating Gravity	Coal						Pct Coal Lighter Than 1.70 Sp Gr
		Pct Refuse in Coal			Pct Coal in Refuse			
		+10 Mesh	—10 Mesh	Total	+10 Mesh	—10 Mesh	Total	
1	1.90	3.36	6.60	5.56	1.72	6.56	5.19	4.5
2	2.0	2.96	8.16	6.57	2.24	5.80	4.57	3.4
3	2.05?	1.52	6.76	4.64	10.80	6.40	7.30	4.8

Example No. 5

Anthracite fines from North Africa.
Separator 6 in., cone 60°.
Size of feed, 5x0.5 mm (approx. 4x30 mesh).
Pressure, 19 psi.
Orifice feed inlet, $1\frac{1}{4}$ in.
Orifice vortex (top outlet), $1\frac{3}{8}$ in.
Orifice apex (bottom outlet) diameters variable.
Medium, Magnetite, —100 mesh, 98 pct —325 mesh.
Specific gravity of pulp medium feed, variable.

Test No.	Pct Weight			Pct Ash			Specific Gravities			Apex Diameter, In.
	Raw Coal	Clean Coal	Refuse	Raw Coal	Clean Coal	Refuse	Feed	Vortex	Apex	
1	100.0	12.8	87.2	27.38	3.19	30.93	1.46	1.15	2.20	0.90
2	100.0	19.5	80.5	29.24	2.63	35.69	1.46			0.85
3	100.0	65.6	34.4	27.51	3.14	73.98	1.46	1.19	2.25	0.80
4	100.0	73.4	26.6	31.28	10.94	87.39	1.66	1.41	2.62	0.80
5	100.0	72.6	27.4	29.73	8.92	84.86	1.66			0.85
6	100.0	72.0	28.0	29.76	8.43	84.61	1.66	1.34	2.40	0.90

Screen Analysis of Raw Coal

Mesh	Pct Weight	Cum. Pct Weight
+4	9.6	9.6
—4x6	20.7	30.3
—6x12	58.0	88.3
—12x16	4.0	92.3
—16x30	2.7	95.0
—30x50	1.2	96.2
—50x0	3.8	100.0

Example No. 6

Anthracite silt bank fines.
Size range of feed, 3/16 in. x 0.
Screen analysis, raw coal feed.

Size	Pct Wt.	Pct Ash
—3/16x3/32 in.	3.0	23.0
—3/32x3/64 in.	36.0	21.0
—3/64 in. x 50 mesh	52.0	22.6
—50 mesh	9.0	24.2
Total	100.0	22.2

Separator 6 in., cone 20°.
Pressure, 25 psi.
Orifice feed inlet, 2 in.
Orifice vortex (top outlet), 2 in.
Orifice apex (bottom outlet), ⅛ in.
Feed rate, 4/10 tph, Tests 1-3; 3-7/10 tph, Test 4.
Medium used, Magnetite.

Test No.	Feed Pct Ash	Clean Coal		Refuse		Sp Gr Medium Solids in Feed
		Pct Wt.	Pct Ash	Pct Wt.	Pct Ash	
1	20.03	86.19	11.60	13.81	72.62	1.38
2	21.95	80.10	10.54	19.90	67.91	1.30
3	21.14	83.75	11.20	16.25	72.30	1.42
4	22.94	79.15	11.07	20.85	67.97	1.40

Sink-and-Float Data on Separated Products

Pct Weight in Products	Size Fraction	Test 1		Test 2		Test 3		Test 4	
		Coal	Refuse	Coal	Refuse	Coal	Refuse	Coal	Refuse
Float on 1.70	+10	87.65	8.78	93.34	7.50	89.48	2.46	87.27	13.54
	—10	87.54	9.38	89.72	10.69	88.76	7.41	87.54	19.95
Sink 1.70	+10	2.84	1.99	0.99	1.86	1.56	0.64	3.71	1.08
Float on 1.75	—10	0.69	0.63	1.58	1.45	0.80	0.82	0.09	2.48
Sink 1.75	+10	2.06	0.63	2.13	3.27	2.00	0.69	2.90	2.35
Float on 1.80	—10	2.07	0.99	1.63	1.43	1.93	0.78	2.07	0.88
Sink 1.80	+10	2.25	1.96	1.38	3.68	2.04	2.01	2.41	3.22
Float on 1.85	—10	2.37	1.66	2.16	2.69	2.16	2.31	2.37	2.23
Sink in 1.85	+10	5.20	89.64	2.16	83.69	4.92	94.20	4.61	80.81
	—10	7.36	87.14	4.91	83.74	6.35	88.68	7.36	74.96

Example No. 7

Anthracite fines, current fresh mined coal.
Size of feed, —⅛ in. x 48 mesh.
Analysis, raw coal feed.

Size	Pct Weight	Pct Weight Cum.	Pct Ash Ind.	Pct Ash Cum.
—⅛ in. x 10 mesh	51.15	51.15	18.62	18.62
—10x28 mesh	28.72	79.87	23.23	20.28
—28x48 mesh	12.85	92.72	28.24	21.38
—48 mesh	7.28	7.28	33.31	22.25
Total		100.00		22.25

Type of cone, 60° angle.
Pressure, 20 psi.
Orifice feed inlet, 1⅛ in.
Orifice vortex (top outlet), 1½ in.
Orifice apex (bottom outlet), 0.765 in.
Feed rate, 1½ tph.
Medium used, Magnetite, 80 pct —325 mesh.
Specific gravities: feed, 1.45; vortex, 1.32; apex, 2.22.

Analyses of Separated Products

Size	Clean Coal			Refuse		
	Pct Weights			Pct Weights		
	of Raw Feed	of Product	Pct Ash	of Raw Feed	of Product	Pct Ash
—¼ in. x 10 mesh	44.80	53.39	10.71	6.35	39.51	74.44
—10x28 mesh	23.19	27.63	11.02	5.53	34.37	74.45
—¼ in. x 28 mesh	67.99	81.02	10.82	11.88	73.88	74.44
—28x48 mesh	9.99	11.90	14.23	2.86	17.79	77.16
—¼ in. x 48 mesh	77.98	92.92	11.25	14.74	91.67	74.91
—48 mesh	5.94	7.08	25.15	1.34	8.33	69.49
Total	83.92	100.00	12.24	16.08	100.00	74.51

Example No. 8

Anthracite fines.

On this same feed as example 7, the effect of substituting a cone having an angle of 20° instead of 60°, with all other operating variables the same, resulted in a decreased recovery of coal, but a higher grade product, as shown by the following figures:

Size	Clean Coal			Refuse		
	Pct Weights			Pct Weights		
	of Raw Feed	of Product	Pct Ash	of Raw Feed	of Product	Pct Ash
—¼ in. x 10 mesh	36.38	52.13	7.20	13.61	45.06	50.07
—10x28 mesh	21.11	30.25	7.91	9.55	31.62	53.30
—¼ in. x 28 mesh	57.49	82.38	7.46	23.16	76.68	51.40
—28x48 mesh	8.46	12.12	9.41	5.12	16.95	62.07
—¼ in. x 48 mesh	65.95	94.50	7.71	28.28	93.63	53.37
—48 mesh	3.84	5.50	17.69	1.93	6.37	66.44
Total	69.79	100.00	8.26	30.21	100.00	54.17

Dutch State Mines Fine Coal Cyclone Separator Plant Using Slate Medium: For the past two years, the Dutch State Mines have been operating a commercial size plant for recovery of bituminous fines, using 350 mm (13¾ in.) diam cyclone separators.

This plant, which is installed in the Emma Washery, has a capacity of 50 tph of run-of-mine coal of a size range of 8x0.5 mm (0.315 in. x 30 mesh).

The flowsheet employed in this plant is shown in fig. 4.

The fine screen undersize from the main plant is conveyed by elevator (*1*) to a 5x12 ft Allis-Chalmers Lohead presizing screen (*2*) where the +8 mm (approximately 5/16 in.) sizes are removed and returned to the main washing plant.

The —8 mm sizes flow by gravity to a mixing sump (*3*) and are pumped from there to a 5x12 ft Allis-Chalmers Lohead screen (*4*) equipped with 0.5 mm (approximately 30 mesh) openings. The undersize, or —30-mesh sizes from this screen, is used to furnish the autogenous (slate slime) medium used in the operation of this cyclone plant. In the first step in this utilization, the fines are classified roughly by means of a dam placed across the width of the sloping hopper underneath the above-mentioned screen. The underflow of the dam, that is the coarser portion of the —30-mesh sizes, flows to a 13¾ in. cyclone thickener (*5*). The apex discharge (heavy solids) of the thickener is sent to the main plant for use as medium in the Baum washers. The vortex discharge from (*5*) is returned to the desliming screen (*4*). The overflow from the dam, placed in the hopper under this screen, flows to a slate-slime (medium) surge tank (*6*). Excess overflow from the latter flows to waste. The underflow is pumped to two 13¾ in. cyclone thickeners, (*7*). The vortex discharges from these thickeners flow back to the surge tank (*6*), while the apex discharge (thickened medium) joins the washings from the refuse screen (*10*) and eventually finds its way to (*12*), one of the two flotation machines in the medium regeneration circuit. Here the coal is removed to give a coal-free slate medium, the further disposition of which will be described later.

Returning to the oversize, that is the —8x0.5 mm (—5/16 in. x 30 mesh) of screen (*4*), this product is collected in a constant level feed box equipped with equally spaced outlets for supplying this feed (together with fine slate medium in correct proportion) to four 13¾ in. cyclone separators (*8*). The static head is sufficient to introduce the feed and medium solids at the equivalent of 19.1 psi to the separators. Here the coal and refuse solids are separated at a gravity equivalent to 1.45. The vortex discharge, carrying the separated coal (75 pct weight of the cyclone separator feed coal) flows to a 5x 12 ft Allis-Chalmers Lohead screen (*9*) equipped with 30-mesh screen. Oversize of the screen goes to finished product storage. The screen undersize (medium plus any degraded coal that may have formed during the preceding operations) flows by gravity to the feed end of the 5x12 ft Allis-Chalmers Lohead refuse screen (*10*) where it is used to dilute the dense apex discharge of the cyclone separators (*8*) before passing over the screen and thus assists in removing the medium solids from the —8 mm x 30 mesh refuse particles.

The undersize from the coal screen (*9*) and the refuse screen (*10*) flows to the regeneration flotation machine (*12*), previously mentioned in the description of this flowsheet, where any —30-mesh coal fines are removed.

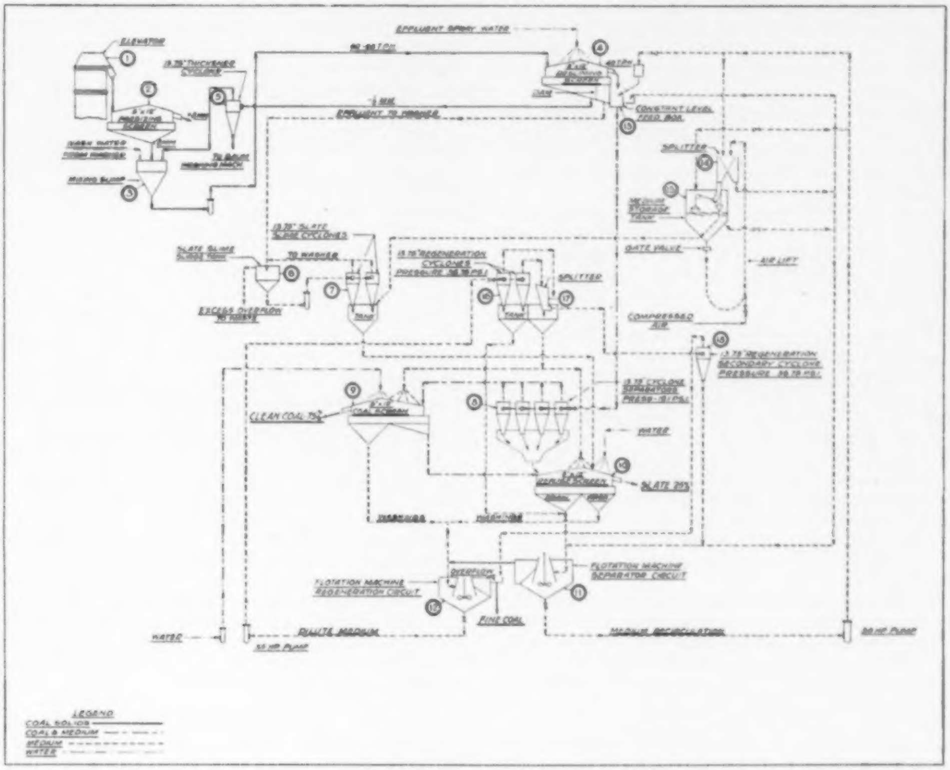

Fig. 4—Dutch State Mines fine coal cyclone washer plant, Emma mine.

The drainage from the refuse screen (*10*) flows by gravity to a regeneration flotation machine (*11*). The coal floated in the latter is retreated in the other regeneration flotation machine (*12*).

The oversize from the refuse screen (*10*) is a finished product and is rejected to waste.

The tailings, or fine slate medium, from the regeneration flotation machines (*11*) and (*12*) are handled in two separate circuits as follows: (*a*) The flotation tailing from (*12*) is pumped at a pressure of 36.75 psi to two 13¾ in. cyclone thickeners (*16*) operated in parallel. The thickened solids (apex discharge) from both thickeners are combined and returned by gravity to the regeneration flotation machine (*11*). The vortex discharge of one of the cyclone separators (*16*) is used for spraying the solids on refuse screen (*10*). A portion of the vortex discharge of the other cyclone thickener (*16*) also may be used for the same purpose just mentioned, or a portion of it may be diverted by a splitter (*17*) and fed to a secondary cyclone thickener (*18*) at a pressure of 36.75 psi. The apex discharge from the latter is fed to the regeneration flotation machine (*11*) and vortex overflow is used to assist the flow and removal of the fine coal solids from the regeneration flotation machine (*12*). (*b*) The flotation tailing from (*11*) is pumped to the constant level feed box (*13*) where it is admixed with the incoming —8 mm x 30-mesh raw coal feed solids in such amount as required. A valve arrangement permits any excess over the amount required for admixture with the raw coal feed to by-pass to a splitter arrangement (*14*). This diverts part of the flow to a constant-head medium storage tank (*15*) equipped with a float and regulating device (schematically described in the flowsheet of fig. 4). The other portion of the flow returns by gravity to the regeneration flotation machine (*11*).

The medium storage tank is provided with a gate valve and airlift for recirculating medium within the storage circuit and for maintaining the medium solids in uniform suspension.

Summary: The results of pilot-plant testing with the Dutch State Mines cyclone separator using magnetite medium have shown that this new process utilizing powerful centrifugal-centripetal forces is capable of effecting excellent separation of coal from refuse in the size range of ⅜ in. x 48 mesh. In the case of some of the coals tested, fairly good separation was made even on the —48x65 mesh fraction. However, in general, separating efficiency was found to drop off rapidly below 65 mesh. In view of this fact, it is necessary that means be provided to remove —48 mesh or —65-mesh sizes from the feed before treatment of it in the cyclone sepa-

rator. Alternatively, if these fine sizes are not removed before the feed is introduced into the cyclone separator, it may be necessary to remove them later from the recovered coal in order to obtain the desired grade.

In the range of —⅜ in. x 48 mesh the separations on the various size fractions are uniformly good. Coal of excellent grade is produced and recoveries closely approach theoretical as developed from washability studies with heavy liquids.

These pilot plant tests have shown that magnetite medium is ideally suited for separating bituminous as well as anthracite fines, from the standpoint of control of the operation, simplicity of flowsheet, and ease and efficiency of recovery of the medium for re-use.

The separating gravity has been found to be conveniently regulated and controlled by: (*a*) the specific gravity of the medium, (*b*) diameter of the apex discharge (refuse) opening, and (*c*) pressure at which the feed enters the cyclone separator.

When separating at low gravities, variations in the specific gravity of the medium entering the cyclone cause a correspondingly greater change in the separating gravity, but as the separating gravity increases, variations in the separating gravity of the entering medium have less effect. Although not essential, automatic control of the feed gravity may be advisable.

The gravity of separation is sufficiently sensitive to changes in the diameter of the discharge opening so that an automatically regulated discharge valve often can be justified in the interests of close control of the size of the discharge opening as well as reduction of wear at this point. In this connection, the Dutch State Mines engineers have developed a special type of rubber valve for closely regulating the size of the opening of the apex discharge on the cyclones operating at the Emma mine washery in Holland.

On the basis of their experience in operating cyclone separators with —325-mesh slate medium, the Dutch State Mines engineers recommend that the specific gravities of both the separatory medium and the separation effected by the cyclone should not differ greatly for maximum efficiency and ease of operation, because of the lesser sensitivity of the medium to fluctuations in feed gravity. On the other hand, experience with a somewhat coarser magnetite medium in the Cyanamid pilot plant indicates that maximum efficiency may be obtained when there is a definite difference between the gravities of the feed and separation, and that in some cases efficiency is decreased by any change in this gravity differential. It is further concluded that the volumetric distribution of the float-and-sink products affect the choice of the feed gravity and the diameter of the discharge opening in the selection of any particular gravity of separation. Where a feed with a full range of sizes is being treated, the matter of medium recovery requires careful consideration. Experience in the Cyanamid pilot plant indicates that it is difficult to drain and wash magnetite medium solids and the separated products from the cyclone separator on a screen much finer than about 10 mesh. If the feed contains only a minor amount of sizes coarser than 10 mesh, it may be desirable to omit any screening operation, and send the separated products directly to magnetic separators, as shown in fig. 2. Under such conditions, a sufficient number of magnetic separators, of proper size, must be provided to recover and clean continuously the magnetite. The amount to be cleaned will be about three times the weight of the feed solids. That is, if the feed to the cyclone separator amounts to 10 tph, 30 tons of magnetite must be recovered, cleaned, and recycled back to the cyclone separator.

When operating with cyclone separators of metal construction and using ferrosilicon or magnetite media, experience in the Cyanamid pilot plant indicates that considerable wear occurs toward the lower end, particularly at the apex.

In the commercial plant operated by the Dutch State Mines, an automatic, rubber valve is used at the apex discharge. This valve has a life of about three to four weeks. The other parts of the cyclones operating at this plant are sectionalized and are constructed of cheap, easily replaceable cast iron. The section nearest the apex discharge has been found to last about one month. The other parts have a life up to seven months, depending on the diameter of the section.

Although the Dutch State Mines engineers have developed a rubber liner for installing inside the cyclone separators, their present feeling is that for their own particular operations cheap cast-iron cast parts probably will be cheaper than a rubber-lined cyclone which would have a higher initial cost.

In this country, a well-known manufacturer of concentrating equipment has developed 3-in., 6-in., and 12-in. diam commercial type cyclone separators. The two smaller size cyclones have either rubber-lined conical sections or are constructed of hardened Meehanite. For the 12-in. size, both the feed and conical sections are rubber-lined.

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Automatic Controls on Sand Pumps

by William B. Stephenson

The paper describes efficient and effective methods of automatically controlling sand pump installations. Particular reference is made to liquid-level controls actuating variable speed pump-driving units. Included is a discussion of various combinations of equipment, with schematic drawings.

HERETOFORE many sand pump installations in the mining and metallurgical field involved guesswork as to the size of the pump and then simply direct-connecting it to a constant speed motor which was often large enough to do twice the work required. Considerable thought was given to mill location in an effort to avoid as much pumping as possible. Hillside design of mills with gravity flow

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of tailing was much to be desired. Power costs were low, construction was relatively cheap, and labor in many places meant nothing in comparison to the values derived from the ores being treated.

Today most of these conditions are reversed. Ores are becoming more complex with lower values per ton of ore treated. Power is more expensive, construction is higher, and labor definitely takes a very important place in the profit and loss statement.

Each piece of equipment incorporated in the design of a new mill is selected to provide highest efficiency based on careful metallurgical analysis of the ore to be treated both in good and poor markets. Each is designed with its flexibility in mind and with provision for adjustments in its performance to meet actual conditions in the operation of the mill.

Sand pumps have taken an important position in mill design. Operators the world over are relying more and more on the performance of a sand pump in the efficient operating of their plant. Many ordinary jobs are being done today with pumps driven through adjustable pitch diameter V belt drives in order that changes in pump speed can be made easily to meet actual operating conditions. Operating costs have long since proved the folly of operating a pump at too high a speed for the volume and head to be overcome. Metallurgical results have shown the benefits derived from a smooth flow as contrasted with a surging flow from an uncontrolled pump. Construction costs have risen to such an extent that surge bins and other means formerly employed must be omitted from today's flowsheet.

Several installations of considerable size and involving the use of automatic pump speed control have proved the adaptability of such controls since they were placed in service in recent years.

In the following presentation each system discussed and illustrated schematically has been installed in one or more instances and has proved itself reliable and definitely economical from the standpoint of capital investment, operation and maintenance.

Variable Volume-Head Speed Control: Probably the most popular, effective and efficient automatic control setup for sand pumping installations is the one shown schematically in fig. 1. Commonly used

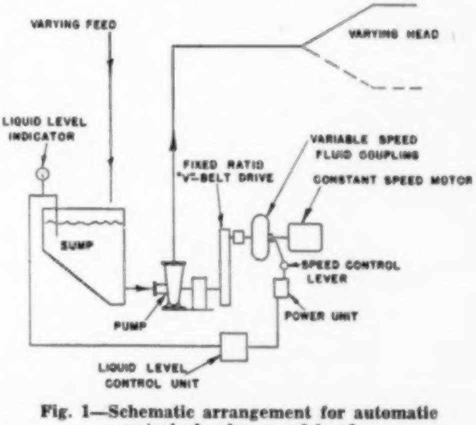

Fig. 1—Schematic arrangement for automatic control of volume and head.

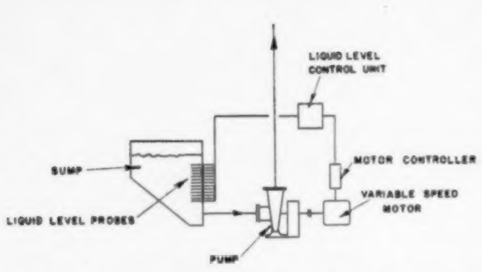

Fig. 2—Schematic arrangement for automatic speed control from liquid level of sump.

in connection with tailing disposal, this control equipment provides for handling a variable volume against a variable head without manual supervision. This type of control is particularly effective for a mill handling a constant tonnage of feed consisting of varying ores, which results in fluctuations in volume of tailing.

In cases where a tailing dam distribution system is employed and this control system is used the amount of pipeline can be changed at the will of the dam operator without concern as to results at the pumphouse.

Fig. 1 shows a conventional centrifugal sand pump being fed with a variable volume of pulp from a sump. The pump in this case is driven from a high speed squirrel cage motor through a variable speed hydraulic coupling and a fixed ratio V belt drive. The output speed of the coupling and consequently the speed of the sand pump are controlled by the positioning of an adjustable lever from the power unit of the liquid level control system. Any change or attempted change in the liquid level in the sump results in an increase or decrease in the pump speed.

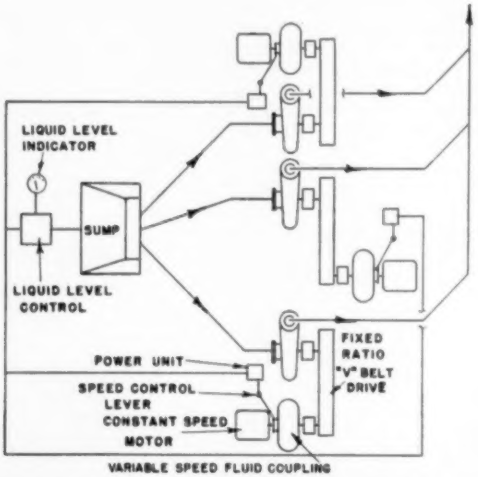

Fig. 3—Schematic arrangement for automatic control of volume and head. Three pumps in parallel.

This liquid level control system involves the use of low pressure air bubbled through a tube submerged in the pulp in the sump. Changes in pulp level create more or less resistance to the flow of the low pressure air. These changes are picked up by the receiving and transmitting instrument which in turn actuates the power unit to move the coupling speed control lever.

Instead of hydraulic couplings, some installations use direct current motors with which a rheostat is automatically adjusted. Wound rotor motors using automatically positioned drum controllers and even wound rotor motors using probes in the sump for liquid level control have been successful. Fig. 2 shows such an arrangement of equipment which does a good job but does not provide the smooth, non-step speed variation of the hydraulic, electromagnetic or direct current units.

Various combinations of pump equipment can be used with any of these types of control. One installation involving the handling of a wide range in

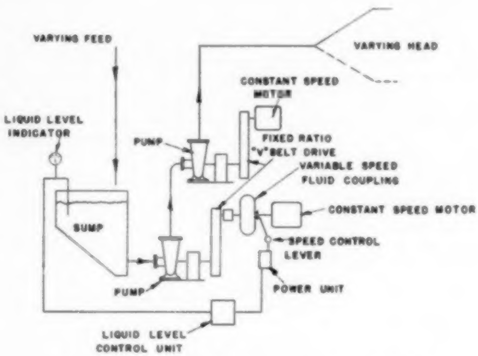

Fig. 4—Schematic arrangement for automatic control of volume and head pumps in series.

volumes uses three 12 in. pumps operating in parallel, each with variable speed hydraulic couplings controlled from a central panel tied in with the liquid level of a common sump as shown in fig. 3.

In cases where the total head on a system is greater than can be handled economically by one pump, two or three pump units connected in series in one pump station can be used. Fig. 4 shows such an arrangement with the first pump in the series driven through a variable speed controlled power unit regulated from the pulp level in the sump.

For slight changes in volume and only minor changes in head, fig. 5 shows the arrangement of equipment where the volume exceeded reasonable capacity limits of one 12 in. pump. Two of the three pumps shown are in constant operation, splitting the volume involved between the two. No. 1 pump is the variable speed unit, utilizing the same arrangement of control equipment as shown in fig. 1. No. 2

pump is a constant speed unit. The total volume handled in this case amounts to about 8000 gpm against a total head on each pump of about 26 ft. The third pump shown is a standby unit for either of the other two and is driven from a wound rotor motor with a drum controller for manual speed variation.

Constant Discharge Volume Control: Possibly more closely allied with the chemical field is the problem of pumping a constant volume. In processes where batching is necessary, tanks of considerable size must be pumped out. To put the suction of a centrifugal pump on the bottom of one of these tanks without some control definitely means that the pump will discharge an ever decreasing volume as the tank is emptied.

Fig. 6 shows the schematic arrangement of equipment for automatically maintaining a constant flow through a centrifugal pump as applied in the above case. A rubber-lined pinch type of valve is used on the tank discharge pipe leading to a transfer sump.

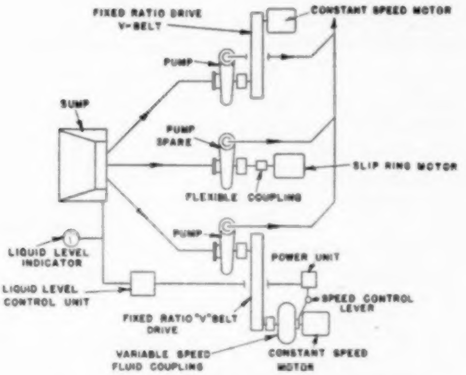

Fig. 5—Schematic arrangement for volume control. Two pumps in parallel, third pump spare.

The pump, taking its feed from the transfer sump, is driven from a squirrel cage motor through a fixed ratio V belt drive and is set, as to speed, to deliver a given volume against a constant head.

A liquid level control unit measures the level in the transfer sump and energizes the pinch valve to open or close, providing an increase or decrease in flow of pulp from the tank to satisfy the requirements of the sand pump.

Filter Level Control: Through the use of basically the same equipment as shown in fig. 1 it is possible to control the liquid level of the receiving vessel through changes in the speed of the pump. Fig. 7 shows the arrangement of the equipment in this case.

A good example of application of this arrangement is in controlling the level in a filter. Through control at its maximum point, higher efficiency may

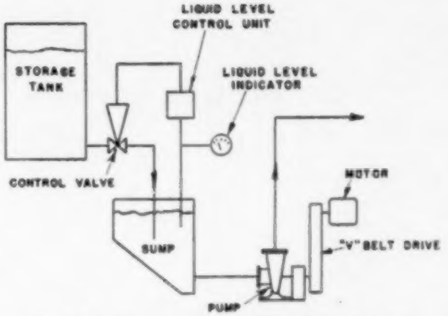

Fig. 6—Schematic arrangement for maintaining constant flow.

be expected. In varying grades of concentrates, effectiveness of filter cloths will have its effect on the level in the filter pan. Each change in level or tendency to change is picked up by the control system and results in an increase or decrease in pump speed.

One installation has gone so far as to direct-connect the suction of the sand pump to the underflow of a thickener. This particular installation involves the use of direct current motor and a field rheostat positioned by the power unit of the level control. An electronic tube-type converter is used to change alternating current to direct current for the small motor.

Density Control: There have been several installations made of equipment designed to control the speed of pumps according to density of the pulp being handled. Most of these are to be found in Florida in the phosphate field and handle large volumes of pulp within not too close density ranges. One particular installation depends on its density control from the load on the thickener rake motor. With an increase in load of the motor, a pinch valve is automatically opened, thus relieving the load on the rake and discharging a variable volume to the sump beneatn. At this point liquid level control comes into play and adjusts the speed of the pump to the

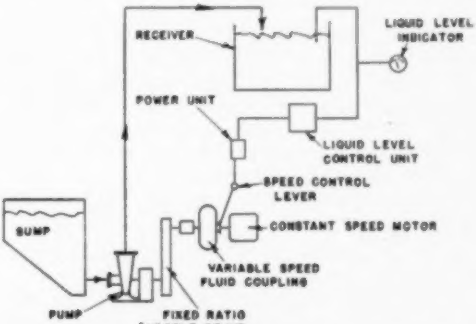

Fig. 7—Schematic arrangement for automatic control of liquid level in receiver.

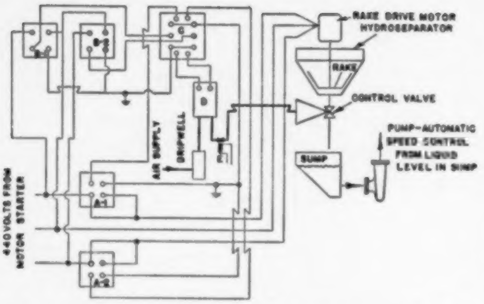

Fig. 8—Schematic arrangement for automatic density control of hydroseparator underflow.

A-1 and A-2—Current transformer
B-1 and B-2—Potential transformer
C—Thermal converter
D—Recording controller
E—Solenoid air valve (to close on power failure) Air piping shown heavy.

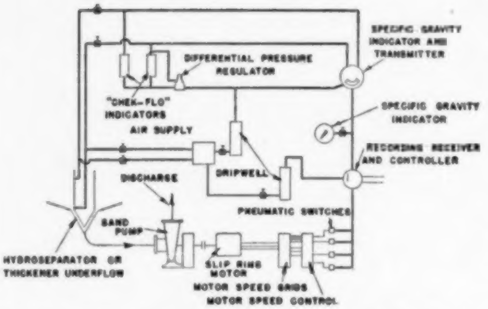

Fig. 9—Schematic arrangement for automatic density pump speed control as applied to "Torque tube" type thickeners and hydroseparators.

volume to be handled. Fig. 8 shows the arrangement of the equipment used in this case.

Another such installation uses a control system involving pressure differential readings continously taken through taps in the torque tube of the thickener mast near the cone. Changes in these readings mean a change in density of the mass at that point and through control equipment automatically result in changes of pump speed. This arrangement of equipment is shown in fig. 9.

Control Accessories: Most of this discussion has been devoted to the control of the speed of a pump. Fig. 10 shows a rather ingenious device recently seen in use in the west in connection with control of the feed to a sand pump. A considerable volume of tailing is being reclaimed, hauled some distance, repulped, and pumped against very unusual heads. No unsurmountable difficulties were encountered except for an unexpected amount of trash which continually plugged the suction, the pump, or the distribution lines.

The device as shown is simple but very effective. Instead of the usual open end suction in a mixing tank, this suction is a capped, perforated pipe in a vertical position. Over the perforation is a close fitting collar which is continually moved up and down. The result is uninterrupted pumping between week-end shut downs during which the accumulated trash in the tank bottom is cleaned out.

On a recent visit to Mexico, another individual development was seen which may be of interest. At this particular plant, thickened concentrates going to the filters are constantly troublesome because of their slimy nature. From our observation, it is doubtful that any automatic control on filter level would ever work at this plant. Filter bags are continually blinding.

The thickener discharge flows by gravity through a pipe with a gooseneck on it connected by a swivel joint to the tank bottom. By means of a system of ropes and pulleys going to the remote filter floor, it is possible for the operator to control the density of the pulp entering the filter. It is amazing to watch the underflow thicken as the gooseneck pipe is raised. The change from a thin pulp in low position to a thick pulp in high position is almost instantaneous. The flow decreases with an increase in density and the pump, running at constant speed, gulps and gasps and discharges in surges, but the operator does have control over his filter level when it is required.

Summary

Summing up, there is no new piece of apparatus used in most known sand pump installations which are automatically controlled. Systems as developed today, to handle a particular problem, simply involve a combination of thoroughly proven apparatus. To determine what is most necessary to be controlled is the important point and the benefits derived from controlled equipment are numerous.

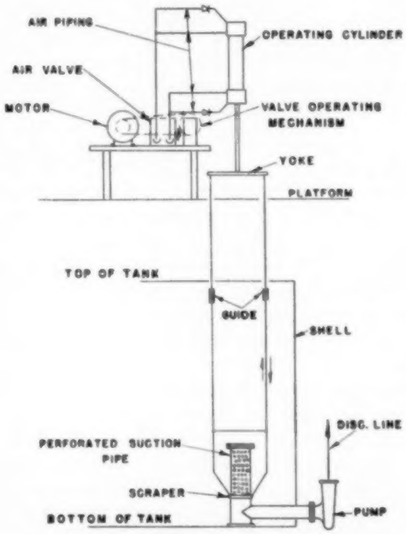

Fig. 10—Schematic arrangement of continuous operating suction strainer cleaner.

Low-Temperature Coke as a Reactive Carbon

by C. E. Lesher

THIS paper reports a study of the reactivity of 950°F and 1650°F cokes as measured by relative rates of reduction of iron oxides at temperatures up to 2200°F. Previous work cited shows general acceptance of the theory that reduction by carbon is a gaseous reaction, and that kind and character of carbon as well as particle size have measurable effect on the velocity of reaction. As will be shown, the data obtained in this study confirm those conclusions. The work was not designed to examine iron oxide reduction equilibrium, but if reaction velocity be defined as the speed with which "a reaction tends to approach conditions of equilibrium," the data here presented may be considered as a study of reaction rates, and the relative degree of reduction to metallic iron as the measure of reactivity.

Three standardized combinations of Lake Superior brown iron ore with carbon were tested by similar procedures. One combination was a mechanical mixture of carefully sized high-temperature coke (1650°F) with the ore. The second was a mechanical mixture of the ore with Disco* obtained by carbonizing the identical coal at 950°F. The third was an agglomerate prepared by carbonizing the coal and ore at 950°F, premixed in proportions to give as nearly as possible the same relative amounts of carbon and ore as the mechanical mixtures. This agglomerate, obtained by heating the finely divided ore (through 30 mesh) with coking coal through the plastic temperature range so as to form solid aggregates, gives a product in which the oxide particles are impregnated with, and intimately bound together with low-temperature coke.

* "Disco" is the registered trade name of a solid fuel made by the Disco process of low-temperature carbonization of coal.

The agglomerate—ore-Disco—was most active in oxide reduction; the mechanical mixtures of Disco and ore next in order, with coke the least reactive.

General Discussion: Carbon exists in many forms and it is well known that the form or nature of the carbon used in reduction of oxides is related to the critical temperature of reduction. Sugar carbon, charcoal, and lampblack are forms of carbon that will reduce oxides at lower temperatures than high-temperature coke, and coke will, in turn, give a lower critical reduction temperature than graphite. There have been many investigations of this characteristic of carbons. Johnson[1] reported a difference of 130°F (70°C) in the critical reduction temperature of zinc oxide as between charcoal 1891°F (1033°C) and Acheson graphite turnings 2021°F (1105°C) with zinc oxide. Bodenstein[2] using charcoal and coke, found a difference of 138°F (77°C) comparing an experimental figure of 2066°F (1130°C) for coke and 1928°F (1053°C) for charcoal, in the reduction of zinc oxide.

He concluded that this is very marked and observed that the "type of carbon merely raises or lowers the temperature at which rapid reaction takes place." Comparing the effectiveness of types of carbon in reduction of zinc oxide, it was found that a "brown coal coke" gave 97 pct zinc elimination at 1832°F (1000°C), as compared with 48 pct with "hard coal coke."[3]

A wide range of metallic oxides was studied by Tammann and Sworykin,[4] who found that the temperature at which decomposition of oxides begins depends on the nature of the carbon used. Carbon in the form of graphite, lampblack, and sugar carbon was investigated. Sugar charcoal will reduce Fe_2O_3 to Fe_3O_4 at 842° F (450°C) as compared with 1112°F (600°C) for coke, according to Meyer.[5]

Direct reduction of iron oxides by charcoal begins at 1382°F (750°C), but "first becomes intense" at 1652°F (900°C), whereas with coke, direct reduction begins at 1742°F (950°C), and "first becomes appreciable" at 2012°F (1100°C).[6] The total reduction of the sample under certain conditions when heated in a current of CO with charcoal was about 100 pct for limonite and about 77 pct for magnetite. Using coke under the same conditions, the respective percentages were 75 and 47. In a study of processes for sponge iron[7] by the Bureau of Mines, the conclusion was reached that a low-temperature char from noncoking subbituminous coal is the most satisfactory solid reducing agent.

In a critical study of zinc smelting from a theoretical viewpoint Maier[8] concluded that the reduction is by CO, that the reaction between ZnO and CO is intrinsically more rapid than the subsequent reduction of CO_2 by C, which is limited by diffusion rates, which in part effectively limits the smelting process. Maier said that the operation is improved with the activity of the reducing carbon. An active carbon, he said, is one maintaining a low CO_2 content in the retort.

Reactivity of Carbon: One form of carbon is more potent in reducing oxides than another. A carbon that reacts faster than another at a given temperature is said to be more reactive. Reactivity is measured by several methods, using carbon dioxide, air, or steam as reactants.[9] Sebastian and Mayers[10] have developed a method for the determination of absolute reaction rates between coke and oxygen by a study of ignition points under certain conditions.

These and other investigators have established the relative reactivity of types of carbon. Lignite, charcoal, bituminous coal, cokes in the ascending order

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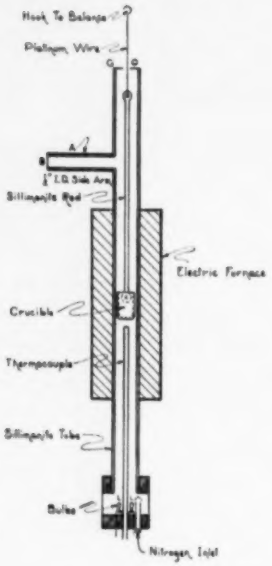

Fig. 1—Furnace tube for gaseous reduction tests.

of temperature of carbonization, are progressively less reactive. The carbon that is the more easily oxidized by CO_2 is the carbon that will be more useful in smelting zinc, to the extent that the rate of reduction of ZnO is dependent on the slower reaction between carbon and CO_2 for its reactant, CO.

Most of the study of reactivity of carbon has been done on coke, from that carbonized at 932°F (500°C) to 1832°F (1000°C). In a study of cokes from five bituminous coals, Reynolds and Davis[9] conclude that the reactivity of coke from a given coal decreases with increase in the carbonizing temperature.

There appears to be a clear parallelism between the reactivity of carbons with the gases mentioned, and their rates of reaction in reduction of metallic oxides. Why one form of carbon is more reactive than another is a question yet to be answered. Reynolds and Davis could find no relation between the rank of the coals and the reactivity of the corresponding cokes. Although cokes made at the same temperatures using five different coals showed a wide range of reactivity, the most reactive low-temperature coke combined with carbon dioxide about twice as rapidly as the least reactive coke made at the same temperature. It has been observed that amorphous forms of carbon are more reactive than crystalline forms.[11]

It is known, of course, that low-temperature cokes yield volatile matter when heated above the temperatures of their formation. The gas given off is mainly hydrogen, which, like CO, will reduce oxides. The rate of gas evolution[9] after the first hour is fairly constant from 932°F (500°C) and 1292°F (700°C) cokes. That is to say, even though a 932°F (500°C) coke will undergo changes in the direction of high-temperature coke when recarbonized, it will not only react with carbon dioxide more rapidly at 1112°F (600°C) and 1292°F (700°C) than at 932°F (500°C), but it is evolving hydrogen with some carbon monoxide and traces of other gases, throughout the heating period.

Influence of Particle Size: The rate at which an oxide is reduced by carbon is not only related to the reactivity of the carbon, but to the particle size of the oxide as well. The finer the particle size of oxide and of carbon and the more intimately they are associated in the reaction zone, the faster the rate of reduction of the oxide by the carbon.

If the reduction is exclusively, or even primarily, a solid to solid reaction, it is exceedingly important that the particles of both oxide and carbon be very small as well as intimately mixed. A flue dust imbedded in low-temperature coke would represent a practical example of such a condition. However, if a solid oxide and carbon do react at all, "the reaction would soon stop since the contact between the (zinc) oxide and carbon would shortly be broken by the vaporization of the products of reaction."[12]

The more generally accepted theory is that oxides are reduced by CO, the reaction giving CO_2, which in turn is reduced by carbon to CO. Thus the oxide is reduced by CO; the CO_2 by carbon. Two solids therefore—the oxide and the carbon—when heated give as end products the metal and carbon dioxide. To initiate the gaseous reactions, some gas, e.g. air (oxygen), CO, or CO_2 must be present in some quantity, however small. It has been suggested that the solids may have sufficient vapor pressure at elevated temperatures to supply this gas,[12] or that there is always sufficient entrained air to initiate the reduction.

In this conception, the metal oxide is reduced and CO is oxidized to CO_2. The molecule CO_2 must in turn be reduced by coming into contact with a molecule of carbon. Under like conditions of temperature and pressure, the time required for reduction of a given quantity of oxide will be governed by the sum of all the times it takes for molecules of CO to travel from the solid carbon to the solid oxide, and as CO_2, back to carbon; that is to say, the rate of diffusion. The shorter the paths, the more rapid the reaction and since surface films impede reaction, the more surface, the more reaction there will be.

Intimacy of contact and fineness of particle may be had by fine grinding, but an impalpable powder so produced would offer almost a maximum of resistance to gas flow. A quiescent mass of dust may have almost infinite surface and yet be relatively impenetrable to both liquids and gases. Whether

Table I. Analyses of Materials Screen Analyses

	Coal	Ore
+4 mesh	0	0
4x8	0.5	
8x14	24.0	
14x28	32.8	
+28 mesh		0
28x48	16.9	24.0
48x100	11.5	28.2
100x200	9.7	33.5
−200	4.6	14.3
	100.0	100.0

Analyses of the Cokes, Dry Basis

Carbonization Temperature	850°F	1652°F
Volatile matter	18.1	2.0
Ash	6.7	11.3
Fixed carbon	75.2	86.7
Sulphur	0.7	0.95
Btu	13,650	12,660

reduction[2, 10-17] be by solid or gas, the particle size is important in determining rate.

Oxide-Carbon Agglomerates: The process by which finely divided oxides are "wrapped up" in "balls" of reactive, low-temperature coke was developed from the Disco process of carbonizing coal. In the Disco process, coking coal and finely divided "breeze" are heated and carbonized in revolving kilns or retorts. The coking coal is softened and the plastic mixture, when coked or baked so that it becomes solid and hard, is the Disco "ball." Substituting iron ore for the breeze gives a "ball" in which each particle of ore is imbedded in coke, being coated with carbon.[18]

Preparation of Standard Samples: Samples of Lake Superior iron ore, low-temperature coke, high-temperature coke, and an agglomerate of ore and low-temperature coke were used in all tests. The cokes were made from low-sulphur coking coal from the Pittsburgh bed. High-temperature coke (900°C, 1652°F) was made from this sample of coal by the Bureau of Mines in the standard AGA-BM retort.

Minus 30-mesh ore used in these tests contained 59.25 pct of iron, equivalent to 84.65 pct of Fe_2O_3. The ore-Disco was made by carbonizing to 850°F in a batch retort a mixture of 60 lb of ore and 40 lb of coal. The product was crushed and the 4x8-mesh size screened out for testing. The low-temperature coke forming the matrix was made under identical conditions with the 850° coke made from coal alone. Screen analyses of ore and coal as charged were as shown in table I.

The agglomerate contained 67.8 pct ore and 32.2 pct low-temperature coke. The calculated volatile matter in the agglomerate was 5.8 pct and fixed carbon 24.1 pct.

Experimental Procedure with Iron Oxide: Two laboratory procedures were followed in the study of reduction of iron oxide. In both, samples of ore and reducing agent were heated in a vertical furnace, suspended in a small capsule or crucible. One procedure was to weigh and record the weight loss progressively; the other to collect and weigh the gases given off progressively during the test. All tests were made in a crucible surrounded by a current of purified nitrogen. The furnace charges were 3 g of the agglomerate or 2.035 g (67.8 pct) of —30-mesh ore and 0.965 g (32.2 pct) of coke. This provided an ample amount of excess carbon which remained in the crucible at the end of the heating period.

Apparatus: The apparatus, fig. 1, consisted of a sillimanite tube 1 in. id and 32 in. long with a side arm at right angles 7 in. from the upper end, supported vertically within a Sentry electric furnace. Temperatures were read with a Brown indicating pyrometer up to 1500°F and with an indicating and controlling Leeds & Northrup potentiometer above 1500°F.

The crucible containing the reactants, ¾ in. od, 9/16 in. id, and 2 in. long, was suspended in the furnace by a sillimanite rod. Connecting the upper end of this rod with one arm of a balance was a platinum wire of such a length as to hang the crucible in the middle zone of the furnace. A slow stream of nitrogen was fed in the bottom of this vertical tube, and allowed to come out around the space between the wire and the edges of the hole in the glass plate, and at the junction of the glass plate and the top of the furnace tube. A cluster of four small light bulbs was placed in the bottom cool part of this long tube so that by having a hole in the bottom of the balance case it was possible to see down the length of the tube to properly align it before starting a test, and until the crucible reached a red heat, after which the light bulbs were unnecessary.

The tip of the protection tube of the thermocouple was located ⅜ in. below the crucible bottom, when the balance arm was in the horizontal position. When studying the gaseous products, the upper end of the tube was sealed after supporting the crucible, and the gas taken out the side arm of the furnace tube.

In preparation for a test by the weight loss method, the crucible was weighed empty and weighed again containing a charge of 3 g. The timing of each test began when current was turned on in the Globar furnace. The heating rate was about 10°F per min, reaching 1000°F at 90 min, 1300°F in 120 min, 1800°F in 170 min, 2000°F in 190 min, and 2200°F in 210 min. Thus the weight loss may be correlated with temperature and with time with considerable accuracy.

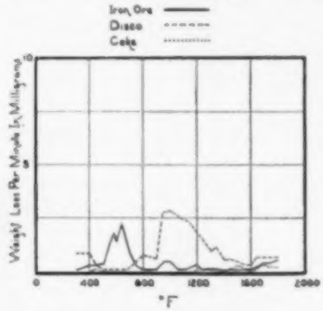

Fig. 2—Weight loss in milligrams per minute from heating 966 mg of coke, 966 mg of Disco and 2034 mg of iron ore.

The weight loss method of testing was used in two ways. The first method was to reach a maximum temperature and hold the crucible at that temperature until there was little or no more loss of weight. At that point the power was shut off, the nitrogen flow increased to insure no sucking back of air. The other weight loss method was to heat to the maximum temperature being studied, and immediately upon reaching that temperature to shut off the power and increase the nitrogen flow in an attempt to cool the furnace and to stop the reaction. In either case, the crucible was cooled before removal from the furnace tube.

The crucible and contents were weighed before and after each test and again after the residue was removed. Crucible plus residue weight was subtracted from the crucible plus charge weight at the start of the test to get overall weight loss, which usually checked very closely with the weight loss as determined while running. The entire residue was ground to —100-mesh in agate mortar, weighed, and a free-iron determination made by the mercuric chloride method.

Test Results with Weight Loss Procedure: The data at various temperatures are presented in figs. 2, 3, and 4. Except for the tests in which ore, coke, and Disco were heated alone, the standard crucible charge was 3 g. The total weight loss of the charge materials when heated alone, fig. 2, was insignificant. The iron ore had its greatest loss at between 600° and 700°, when water of hydration or crystallization was driven off; Disco had its highest loss

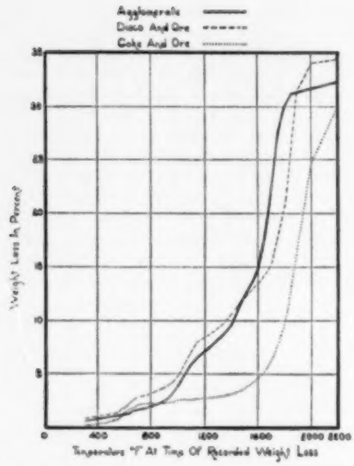

Fig. 3—Cumulative weight losses in percentage of original sample.

between 900° and 1200°, when volatile matter was driven off; and, as was expected, coke alone had very little loss in weight at any point in the test.

Cumulative data for weight losses of the ore with each of the three reactants are given in fig. 3. The cumulative percentages of weight loss for each of the three reactants are closely parallel up to 800°, above which the Disco mixtures lose weight much more rapidly than the coke mixture.

The rates of weight loss expressed in milligrams per minute were calculated from the original data averaged for all tests. These averages were plotted and the weight loss for each 50°F, and 5-min interval, were read from the plots. The figures for weight losses in milligrams per minute are the averages per minute for each such 50° interval. The areas below each of the three curves in fig. 4 are approximately equal, but the respective rates of weight loss are significantly different. The subsidiary peaks at 600° with the mechanical mixtures arise from the loss of water of crystallization in the ore, which had been driven off the agglomerate when it was made. The peaks at 1100° with Disco are attributed about one-half to loss of volatile matter from the Disco and the remainder to reduction of higher oxides of iron to FeO or Fe_3O_4 by the hydrogen in that volatile matter.

Similar peaks in both these curves, and absent from the coke data, are recorded at about 1400°. The accelerated rates at this point are attributed to further reduction in the oxides, for as is shown later, there is very little evidence of reduction to metallic iron at this temperature.

The rate of weight loss—a measure of gas evolution which in turn is a measure of the rate of the reduction of the iron oxides—was most rapid for the Disco agglomerate. Starting upward sharply at 1500°, it rose to a peak at 1750°, and then dropped as sharply as it had risen, to a low point at 1900°.

The rate of reduction of ore with Disco mechanically mixed began to rise rapidly at 1600°, reached a peak at 1850°, and the reaction was far from completion at 2200°.

Coke and ore mixed reacted at more gradual rates; beginning at 1400°, the rise in weight losses of the reactants mounted to a peak at from 1950° to 2000°. The reaction was continuing with considerable speed at 2200°F.

There were 24 test runs in which the weight losses were determined. The preceding data are averaged from these tests in which there were no great departures from the averages.

Gas Recovery Tests: The second series of tests in the same heating furnace and with the same reactants in which the gases involved were collected and weighed gave significant results with respect to the relative rates of reduction of the ore by different reducing carbons. Reproducible results were ob-

Table II. Material Balances and Weights of Gases Collected, in Milligrams

Run No.	Maximum Temperature Momentarily Reached °F	Weight Gases Collected					Material Balance			
		H_2O	CO_2	H_2	CO	Total Gases	Weight Residue	Residues Plus Gases	Weight Charge	Percent Over or Under
Iron Ore and Coke										
61	1,600	94.5	68.0	0.0	2.5	165.0	2,860.0	3,025.0	3,006.0	+0.63
Avg. 49-58	1,800	104.5	180.3	1.0	29.4	315.6	2,721.5	3,037.6	3,005.5	+1.05
66	1,900	96.0	300.0	1.3	185.0	582.3	2,474.0	3,056.3	3,008.0	+1.60
Avg. 52-55	2,000	105.0	323.0	1.68	323.0	753.4	2,249.2	3,002.6	3,008.7	—0.20
Avg. 64-75	2,200	144.0	316.0	5.9	445.0	911.4	2,069.0	2,980.2	3,008.5	—0.96
Iron Ore and Disco										
60	1,600	272.0	139.0	8.1	41.6	460.7	2,595.5	3,056.2	3,007.0	—0.27
68	1,700	223.0	157.0	8.2	76.5	464.7	2,538.0	3,002.7	3,008.0	—0.17
Avg. 48-57	1,800	236.0	222.0	9.8	184.0	652.0	2,351.0	3,003.1	3,004.0	—0.03
65	1,900	224.0	288.0	9.7	406.0	927.7	2,048.5	2,976.2	3,009.0	—1.09
Avg. 51-53	2,000	240.0	299.0	11.13	434.0	984.1	1,995.2	2,979.4	3,008.2	—0.95
Avg. 69-72-73	2,200	237.0	296.0	11.67	47.0	1,015.7	1,972.3	2,988.0	3,007.9	—0.99
Ore-Disco Agglomerate										
70	1,500	167.0	133.0	9.4	44.5	353.9	2,646.0	2,999.9	3,003.0	—0.10
39	1,600	159.5	155.0	11.1	80.0	405.6	2,595.0	3,000.6	3,001.5	—0.03
67	1,700	162.0	272.0	11.9	255.5	701.4	2,286.0	2,987.4	3,001.0	—0.45
Avg. 47-56	1,800	194.5	328.0	13.3	381.0	916.05	2,109.0	3,025.5	2,502.0	+0.77
Avg. 50-54	2,000	196.0	339.0	13.2	403.0	952.5	2,023.2	3,025.7	3,003.5	+0.75
Avg. 62-71 74-76	2,200	200.5	358.0	13.8	443.0	1,018.05	2,038.5	3,054.5	3,003.0	+1.72

tained when the tests were terminated at a predetermined maximum temperature and the produced gases swept out of the train with nitrogen. Attempts to collect and weigh first one and then another gas at short intervals in order to ascertain the current rates of gas evolution were inconclusive. The data in table II and fig. 5 showing the quantities of gases collected were obtained by terminating each test at a predetermined temperature and continuing the flow of nitrogen until the crucible had cooled.

With coke as the reducing agent, the gases evolved below 1600° were mainly water vapor and CO_2 with traces of hydrogen. Between 1800° and 1900°, both CO and CO_2 were given off at their maximum rates and above 2000°, the rates decreased rapidly. The ratios of CO to CO_2 in gases collected did not pass unity until the temperature was above 1900°. A ratio of two parts CO to one part CO_2 represents the minimum ratio possible for reduction to Fe at 1652°F (900°C).[7] With Disco as the reducing agent in mechanical mixture, there was measurable production of CO up to 1600°, about twice as much CO_2 and nearly three times as much water vapor as with coke. From 1700° to a peak at 1900°, CO and CO_2 were evolved at rapid rates; falling off as rapidly in the next 100° to 2000°. The ratio of CO to CO_2 increased rapidly from 0.47 at 1600° to 2.22 at 1900° and 2.28 at 2000°. No water vapor was found in the gases above 1500° and only traces of H_2.

With the agglomerate the reactions were more rapid and at lower temperatures than with the mechanical mixtures. Peaks were reached at 1700° with rates of gas evolution declining to low points at 1900°. Ratios of CO to CO_2 were between 1.8 and 2.0 at 1800° and above.

Material Balances: For the series of tests numbered 47 to 76, in which the gases evolved at successively higher temperatures were weighed, material balances are given in table II. The weight of solid residue at the end of the test is added to the weight of gases collected and this total compared with the weight of original charge as 100. Although several of the individual tests were from 2 to 2.5 pct over, none of the averages, as shown, were as much as 2 pct over or under.

Reduction of Iron Oxides: Results of reducing the charge of iron oxide with the three forms of carbon show that the agglomerate in which the oxide is intimately associated with the carbon is the most reactive, that Disco in mechanical mixture with oxide is less reactive, and that coke is the least reactive of the three carbons tested. Table III records the percentages of total iron that were found to have been reduced to metallic form by the several forms

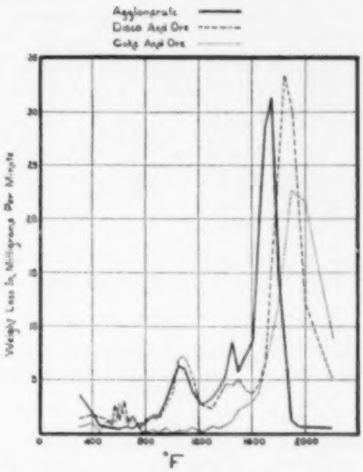

Fig. 4—Weight losses in milligrams per minute on 3-g samples of coke and iron ore, Disco and iron ore, and ore-Disco agglomerate.

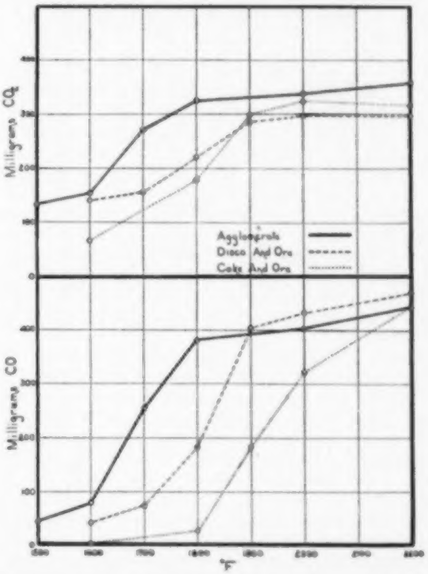

Fig. 5—Total weights of CO_2 and CO evolved to predetermined temperatures momentarily reached. 3-g samples.

Table III. Percentage Reduction of Iron Oxides to Metallic Iron

First Series: Percentage of total oxide iron reduced to metallic iron at maximum temperature momentarily reached.

°F	Reduction Carbon		
	Coke	Disco	Ore-Disco Agglomerate
1,500			0.0
1,600		0.0	6.9
1,700		10.2	85.0
1,800	0.0	37.85	84.2
1,900	34.9	88.1	
2,000	71.0	93.0	88.4
2,200	99.15	100.0	97.7

Second Series: Percentage of total oxide iron reduced to metallic iron at maximum temperature at which held until there was little or no loss of weight.

	Reduction Carbon		
1,400			0.3
1,500		4.35	28.3
1,600	1.98	44.90	75.7
1,700	64.5		
1,800	85.3	86.0	84.3
2,000	95.7	92.3	96.5

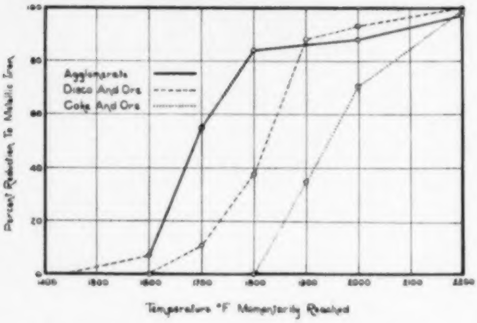

Fig. 6—Percentages of reduction of iron oxide to metallic iron at maximum temperatures momentarily reached.

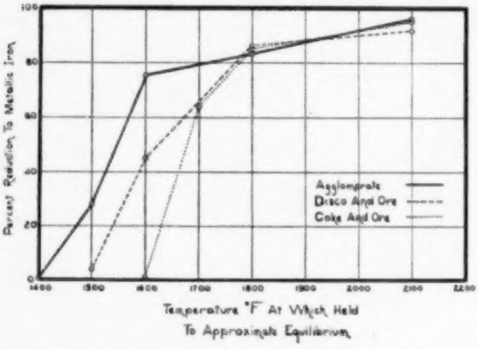

Fig. 7—Percentages of reduction of iron oxide to metallic iron at maximum temperatures at which held until approximate equilibrium.

of carbon at progressively higher retort temperatures. The figures are the averages from 45 tests at the stated temperatures. Figs. 6 and 7 present the data in graphic form. Measurable reduction to metallic iron was had with the agglomerate in the first series at 1600°, and at 1400° in the second series in which the heating was continued at uniform temperature. Reduction of 10 pct of the oxide to metallic iron was recorded with the mechanical mixture of Disco and ore at 1700° in the first series, 45 pct at 1600° in the second. No metallic iron was found at 1800° with coke and ore in the first series, and only 2 pct at 1600° in the second, or prolonged heating test.

Practically complete reduction to metallic iron was found in all tests that reached and were stopped at 2200°. The prolonged heating tests were carried out at maximum temperature of 2000° and gave consistent results for coke and agglomerate. With coke as the reducing carbon, the results, when the tests were stopped at 2000°, were 71 pct reduction as compared with 95.7 pct when the heating was continued. With the agglomerate, comparable figures were 88.4 and 96.5 pct. However, the mechanical mixture of Disco and ore showed approximately the same reduction—93.0 and 92.3 pct for both series.

What is more important than these total figures of percentages of reduction to metallic iron at the top figures are the relative rates of reduction and the more rapid action of the Disco as compared with coke, particularly when in the agglomerate.

Acknowledgments

To Lawrence A. Winter, formerly Research Engineer, Pittsburgh Coal Carbonization Co., predecessor of Disco Co., the author gives full and unstinted credit for the laboratory work and results on which the paper is based. Painstaking, careful laboratory procedures were developed by Mr. Winter over a period of more than two years (1943-1945). The description of methods and the tabulation of results have been prepared from his notes. Mr. Winter was also very helpful in a search of the literature preceding the laboratory investigations.

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aime NEWS

Increase in Quality Technical Papers Results in an Embarrassment of Riches

Either a greater amount of interesting work has been going on in the field of the AIME which inspires writers to record it for publication, or the various Divisional papers and programs committees have been much more active in soliciting such material. In any case, the Institute has been embarrassed by a superfluity of riches in the form of good technical papers, but unfortunately not also in the form of money. Last year 475 technical papers were submitted for Transactions publication, compared with 350 in 1948 and an average of 304 in the preceding five years. Papers accepted for publication last year totaled 282, compared with 209 in 1948 and an average of 216 in the preceding five years. Every year there is some carry-over of papers on which action has not been taken, and with the recent influx of papers, the number carried over naturally also increased, being 238 at the end of last December, compared with 165 a year before, and an average for the preceding five years of 96.

The publication problem that has faced the Institute so far in 1950 thus becomes evident. In 1949, and in the years immediately preceding, the Directors decided to incur substantial deficits rather than to decline good papers for publication. For 1950, on the other hand, with increased income from dues, it was felt that the budget should be balanced and that publication costs should not exceed available income. In the closing months of 1949, when the crest of a wave of incoming papers was reached owing to the Annual Meeting program, a substantial increase in advertising income for the three journals for 1950 was envisaged. Therefore, larger issues of the journals were planned for the first quarter than were later justified.

So far in 1950—that is, for the first six months—143 technical papers, totaling 2145 6 x 9-in. pages, have been published in the three journals, compared with 228 papers, totaling 3343 pages, for the entire year 1949. (The number of pages in 1950 and 1949 has been multiplied by 1.9 to make the data comparable to that for earlier years when the page size was 6 x 9 in., in the accompanying table.)

In brief, many more papers are available for publication in the last half of 1950 than can be published with the available funds. A restriction in the number to be published, or in the total number of pages they occupy, is therefore in order. Auxiliary publication committees are being urged: (1) To limit acceptances of Transactions material strictly to Grade A papers. (2) To urge maximum condensation of papers. (3) To advise Institute headquarters which papers can be postponed for publication in 1951 and which should be published promptly.

Papers are ordinarily written for two purposes: (1) To present at meetings. (2) For publication. Most of those on the technical programs for technical sessions of the Institute are prepared with the idea of publication as well as presentation; practically none are prepared for publication only. A paper is ordinarily condensed considerably when presented orally. It is entirely possible, also, to limit publication to a concise statement of facts, implications, and conclusions. Supporting data, or a more complete paper, can be made available through microfilm, through deposition in central libraries, by direct contact with the author, or by private publication or distribution.

The accompanying table compares the major professional interests of AIME members with the number of pages of Transactions papers that have been published in recent years on subjects of principal interest to them. Apparent illogicalities can be immediately noted. No exact or even approximate agreement between the percentage of AIME members in a certain professional group and the number of papers directed to the specific interests of that group should be expected. The main reason for lack of what might be expected to be a reasonable proportionality is a relatively greater amount of research, and other types of work that lead to papers, in some

PAGES OF TRANSACTIONS PAPERS

(Major Divisional interest of membership, as indicated by cards returned to AIME headquarters, is given for comparison. Pages of Transactions material published in 1949 and 1950 have been multiplied by 1.9 to make the data comparable with earlier years when the page size was 6 x 9 in.)

Name of Division	Pct. of AIME Membership	First 6 Months 1950	1949	1948	Average 1943-1947
Mining, Geology, & Geophysics	27.9	162	218	316	239
(Mining Subdivision)		(95)	(190)	(177)	(105)
(Geology Subdivision)		(59)	(0)	(124)	(86)
(Geophysics Subdivision)		(8)	(28)	(15)	(47)
Minerals Beneficiation	7.2	175	97	190	194
Coal	8.6	102	347	324	151
Industrial Minerals	3.6	152	204	60	106
TOTAL MINING BRANCH	47.3	591	866	890	690
Extractive Metallurgy	6.4	226	305	49	75
Iron and Steel	8.2	241	172	444*	518*
Institute of Metals	11.7	742*	1400*	1310*	511
TOTAL METALS BRANCH	26.3	1209	1877	1803	1104
PETROLEUM BRANCH	24.2	345	600	446	299
Mineral Industry Education	0.6	0	0	5	14
Mineral Economics	1.5	0	0	0	0
TOTAL	100.0	2145	3343	3144	2107

* Ferrous physical metallurgy papers were credited to the Iron and Steel Division until the middle of the year 1948; thereafter all physical metallurgy papers were credited to the Institute of Metals Division.

fields of endeavor than in others. This is conspicuously true for the Institute of Metals Division and its papers on physical metallurgy. The Minerals Beneficiation Division has also recently had more than its usual number of research-type papers to offer. It has not been the policy of the Institute to accept poor papers just because good papers in the field covered were scarce.

It should also be noted that interests of many Institute members spread over several Divisions. For instance, most members of the Industrial Minerals Division—a commodity Division—are also interested in papers of the Mining and Minerals Beneficiation Divisions.

With the more complete organization of the AIME into its present ten Divisions several of these Divisions are doing, and are going to do, a better job of securing good papers representative of progress in their fields. Further, they are going to expect that the best of these papers will be published, and that they will get a fair share of the total. Appropriate officials and committees of the Institute will do their best in the coming months to estimate what the supply of good papers from the various Divisions will be and to make appropriate allocations of publication funds for 1951. Divisional papers and programs and auxiliary publications committees will be consulted and when the decision is made will then know approximately how much material emanating from them can be published. They can then govern their solicitation and recommendations for acceptance of papers accordingly.

W. Peirce, J. Gillson, and M. Haider Head 1951 Ticket of AIME Nominees

O. B. J. Fraser, Chairman of the Nominating Committee, has announced nominations for President, Vice-President, and Directors for 1951. As provided in Art. IX, Sec. 2, of the bylaws, 25 Members or Associate Members may sign and transmit to the Secretary's office prior to Sept. 1 "any complete or partial ticket of nominees."

In such instance, a letter ballot will be forwarded to all members in the United States, Canada, and Mexico, tabulating both the official ballot and any supplementary nominations. If no supplementary nominations are thus received, no letter ballot will be printed, and nominees on the official ballot shall be declared duly elected at the meeting of the board of directors or the executive committee in November.

Nominees for the various offices include: W. M. Peirce, President; J. L. Gillson, Vice-President; M. L. Haider, Vice-President; and T. G. Moore, C. E. Lawall, J. F. Myers, F. W. Libbey, and A. C. Rubel, Directors. A ninth candidate selected by the Board is to be added.

For President

Willis McGerald Peirce, member of the AIME since 1927, is Assistant to the General Manager of the Technical Dept. of the New Jersey Zinc Co., Palmerton, Pa. He has been with the company since 1920 when he received his M.S. degree from Yale. His B.S. was earned at the University of Illinois. He is well known for his work on zinc and for the research organization he has built up. Mr. Peirce was Chairman of the Institute of Metals Div. in 1935, IMD lecturer in 1944, served as Director of the AIME from 1937 to 1943 and from 1949 to date, and as Vice-President from 1940 to 1943.

For Vice-President

Joseph Lincoln Gillson became an AIME member in 1923, when he was an instructor in Mineralogy and Petrography at MIT. He had received his B.S. and M.A. degrees from Northwestern and his Ph.D. from MIT, where, by 1928, he was an Associate Professor. The following year he returned to Northwestern, as Associate Professor of Economic Geology. In 1930 he joined E. I. du Pont de Nemours & Co., Wilmington, Del. Dr. Gillson was Chairman of the Industrial Minerals Div., AIME, in 1947, and was recently Chairman of the AIME Committee on Democratization.

Michael L. Haider was Chairman of the publications committee of the AIME Petroleum Div., for several years, Chairman of the Petroleum Div., in 1945, and active on numerous other committees. He is Vice-President and General Manager of the Production Dept. of the Imperial Oil Co. Ltd., Toronto, going there about four years ago from the Standard Oil Co. (N.J.). After graduation from Stanford in 1927, he worked for the Portland Cement Co., the Richfield Oil Co., and the Carter Oil Co.

For Director

Thomas Gaunt Moore began his present association with The American Metal Co., New York, in 1935 as Field Engineer in the Mining Dept. Following graduation from Harvard in 1931, he became Geologist in charge of the Morococha mine of Cerro de Pasco. After three years in Peru, he returned to the Harvard graduate school for his Ph.D., which he was granted in 1936. Dr. Moore has been active in New York Section affairs and was Section Chairman in 1948.

Charles E. Lawall, Assistant Vice-President of coal properties for the Chesapeake & Ohio Railway, Huntington, W. Va., was Chairman of the Coal Division, AIME, in 1940, and, with a membership dating back to 1914, has been active in AIME affairs and a frequent contributor to technical literature. Dr. Lawall was made President of West Virginia University in 1939, having been Director of its School of Mines. He had been associated with Pittsburgh Testing Laboratories, New Jersey Zinc Co., Bethlehem Steel Co., and Lehigh University.

John F. Myers, Superintendent of Concentration for the Tennessee Copper Co., Copperhill, Tenn., is one of those who made the organization of the Minerals Beneficiation Div., AIME, a *fait accompli* in 1948, and was its first Chairman. Mr. Myers graduated from Colorado School of Mines in 1913 and went to work for the Butte & Superior Copper Co. He was with American Zinc Co. of Tennessee for a year and New Jersey Zinc Co. for 11 years, joining Tennessee Copper in 1926 as Superintendent of Milling.

Fay W. Libbey, with the Dept. of Geology and Mineral Industries of the State of Oregon in Portland, made his entrance into the mining field in 1906 as night foreman for the Nipissing Mines Co., Cobalt, Ont. Two years later he was Superintendent of Vulture Mines Co., Wickenburg, Ariz., going from there to the custom assay office in Phoenix, and then into mine leasing, oil field work, and consulting. He was Chairman of the Oregon Section in 1942.

Albert C. Rubel, Vice-President of the Union Oil Co. of California, Los Angeles, got his B.S. from the University of Arizona in time to be assayer for Magma Copper for three months before going into the Army in 1917. After separation from the 304th Engineers, he became Geologist for the Commonwealth Petroleum Co. and then the Richmond Levering Co. In 1923 he joined Union Oil Co. as a Geologist, becoming a Director in 1936.

Division Nominations for 1951

Coal Division: Chairman, Carroll A. Garner; Chairman-elect, A. L. Barrett; Secretary-Treasurer, D. R. Mitchell; Executive Committee (until 1954), J. T. Ryan, Jr., S. M. Cassidy, N. L. Davis.

Extractive Metallurgy Division: Chairman, T. D. Jones; Secretary, E. O. Kirkendall; Executive Committee (until 1954), L. P. Davidson, R. D. Bradford.

Industrial Minerals Division: Chairman, A. B. Cummins; Secretary-Treasurer, D. G. Runner; Southeastern Vice-Chairman, T. L. Kesler; Rocky Mountain Vice-Chairman, Eugene Callaghan; Eastern Vice-Chairman, H. M. Bannerman; Canadian Vice-Chairman, George F. Jenkins; Western Vice-Chairman, A. C. Bartell; Executive Committee, R. B. Dott, J. A. Barr, Sr., with Paul H. Price as alternate, G. R. Gwinn.

Institute of Metals Division: Chairman, R. M. Brick; Sr. Vice-chairman, W. A. Dean; Vice-chairman; J. H. Scaff; Secretary, E. O. Kirkendall; Executive Committee, J. B. Austin, W. R. Hibbard, Jr., C. H. Samans.

Iron and Steel Division: Chairman, T. L. Joseph; Vice-chairman, W. C. Kitto, J. B. Austin, E. K. Miller; Executive Committee (until 1954): R. W. Campbell, J. A. Bowers, F. L. Toy.

Mineral Economics Division: Chairman, Richard J. Lund; Vice-chairmen, Granville S. Borden, Julian W. Feiss, Robert P. Koenig; Secretary-Treasurer, John H. Melvin; Executive Committee (until 1954), Evan Just, Russell H. Bennett, George W. Josephson.

Mineral Industry Education Division: Chairman, Allison Butts; Vice-chairman, Harry H. Power; Executive Committee (until 1954), Robert M. Brick, George B. Clark, Edward H. Wisser.

Petroleum Division: Chairman, Charles B. Carpenter; Vice-chairmen, Lincoln F. Elkins, Paul R. Turnbull; Executive Committee Thomas C. Frick, John S. Bell.

Student Chapter members at the University of Minnesota and their distinguished guests at the May dinner.

University of Minnesota

Donald H. McLaughlin, as guest speaker at the May meeting of the Minnesota Student Chapter, mentioned the advantages offered to the graduate engineer who participates in AIME activities and then discussed the geology and topography of the Cerro de Pasco mining district of Peru, illustrating with his beautiful colored slides of the district.

Professor E. M. Lambert, who retired in June after 41 years at the School of Mines, was honored by the students at the meeting.

The Chapter also entertained James E. Boyd, R. D. Longyear, C. J. O'Connell and many members of the Minnesota Section, AIME.

New officers of the Chapter are: Arnold G. Connor, President; John H. Goodrich, Vice-President; George R. Remarcke, Secretary; and Harold C. Macnamara, Treasurer.

Coming Events

July 6, AIME, Pennsylvania-Anthracite Section, Irem Temple Country Club, Dallas, Pa.

July 10-14, Engineering Institute of Canada, annual meeting, Royal York Hotel, Toronto.

July 13, AIME, Rio de Janeiro Section, Rio de Janeiro.

July 25, AIME, Manila Section, Elks Club, Dewey Blvd., Manila, P. I.

July 30-31, Mining Assn. of Montana, Hotel Finlen, Butte, Mont.

Aug. 7-19, Chicago International Trade Fair, Chicago, Ill.

Aug. 28-31, American Mining Congress, metal mining convention and exposition, Fair Grounds, Salt Lake City, Utah.

Sept. 1, AIME, Minerals Beneficiation Division, Hotel Utah, Salt Lake City.

Sept. 3-8, American Chemical Society, National Chemical Exposition, Chicago Coliseum, Chicago, Ill.

Sept. 5-9, American Chemical Society, 6th national chemical exposition, Chicago Coliseum, Chicago.

Sept. 10-13, American Institute of Chemical Engineers, Radisson House, Minneapolis, Minn.

Sept. 15-16, National Society of Professional Engineers, Wheeling, W. Va.

Sept. 19-21, American Society of Mechanical Engineers, fall meeting, Hotel Sheraton, Worcester, Mass.

Sept. 20, AIME, Carlsbad Potash Section, Riverside Country Club, Carlsbad, N. Mex.

Sept. 22-23, AIME, El Paso Metals Section, Chihuahua, Chih., Mexico.

Oct. 3-5, American Institute of Electrical Engineers, Baltimore, Md.

Oct. 4-6, AIME, Petroleum Branch, New Orleans, La.

Oct. 9-13, AIME, Washington, D. C., Section, Industrial Minerals Div., and Mineral Economics Div., Shoreham Hotel, Washington, D. C.

Oct. 11-12, AIME, Industrial Minerals Div., Rocky Mt. Section, El Paso, Texas.

Oct. 12, AIME, El Paso Metals Section, El Paso, Texas.

Oct. 12-13, AIME, Southern California Section, Metal, Mining, and Petroleum Branches, Elks Club, Los Angeles, Calif.

Oct. 13, AIME, Southwestern Section, Open Hearth Committee, Iron and Steel Div., Houston, Texas.

Oct. 13-14, International Mining Days, El Paso, Texas.

Oct. 17-20, AIME, Industrial Minerals Div., fall meeting, Norman, Okla.

Oct. 20, AIME, Eastern Section, Open Hearth Committee, Iron and Steel Div., fall meeting, Warwick Hotel, Philadelphia, Pa.

Oct. 20-21, Engineers' Council for Professional Development, annual meeting, Hotel Tudor Arms, Cleveland, Ohio.

Oct. 22-24, American Mining Congress, metal and nonmetallic convention, Biltmore Hotel, Los Angeles.

Oct. 23-25, AIME, Coal Div., and **ASME,** Fuels Div., Hotel Statler, Cleveland.

Oct. 23-27 National Metal Congress and Exposition, International Amphitheater, Chicago, Ill. Participating organizations: AIME, Headquarters, Hotel Sheraton; ASM, Headquarters, Palmer House; American Welding Society, Headquarters, Hotel Sherman; Society for Non-destructive Testing.

Oct. 27, AIME, Southern Ohio Section, Open Hearth Committee, Iron and Steel Div., annual meeting, Deshler-Wallick Hotel, Columbus, Ohio.

Nov. 3, AIME, Pittsburgh Section of Open Hearth Committee, Iron and Steel Div., and Pittsburgh Section, AIME, annual meeting, William Penn Hotel, Pittsburgh.

Nov. 9, American Mining Congress, Coal Div. Conference, William Penn Hotel, Pittsburgh, Pa.

Nov. 16-18, Geological Society of America, annual meeting, Hotel Statler, Washington, D. C.

Nov. 26-Dec. 1, American Society of Mechanical Engineers, annual meeting, Hotel Statler, New York.

Feb. 19-22, 1951, AIME, annual meeting, Jefferson Hotel, St. Louis, Mo. Metals Branch session to be held at th Statler Hotel.

Apr. 2-4 1951, AIME, Open Hearth and Blast Furnace, Coke Oven and Raw Materials Conference, Iron and Steel Div., Statler Hotel, Cleveland, Ohio.

The Drift of Things . . . . as followed by Edward H. Robie

The Tariff and World Problems

Congressional hearings on a proposal to increase the duty on imported crude petroleum from half a cent a gallon to two cents a gallon, and on other matters of interest to various groups in the mineral industry, have brought all the old familiar arguments about the benefits and evils of tariff protection. As to the oil imports, the small "independent" oil producers and the coal producers are the chief protagonists for increasing the duty. They affirm that imported oil is making cut-throat competition which is driving oil and coal-mining companies out of business. Thousands of coal miners are jobless, the health of their children affected, and "even the public schools are imperiled." Also, the security of the country is threatened, for the supply lines of the imported oil would likely be cut in case of war, and it would take a long time to train miners and get domestic dormant mines back into operation. Much the same arguments, plus the complaint that foreign products afford unfair competition because of low labor costs through the use of slave or peon labor, are offered in arguments for increasing the tariffs on many other things.

On the other side of the fence are those that feel that John L. Lewis, by increasing the cost of mining coal and by strikes which have often made coal impossible to get at any price, has hurt the sale of coal much more than has imported oil. The suggestion has been made that the oil industry should send Mr. Lewis a bouquet of orchids every day.

Willard Thorp, Assistant Secretary of State, in opposing the proposed increased tariff, maintained that coal has lost ground to oil and gas for over thirty years and that the influx of foreign oil—now slightly under a million barrels a day—has had limited, if any, force on this trend. He asserted that oil is a vital part of the country's trade program; it is one of the ways that foreign countries pay for American exports. Security in case of war would be seriously threatened, too, for without an American outlet, foreign oil producers would be weakened, yet we would need their aid.

Neither did Mr. Thorp think that imported oil was harming the domestic oil industry to any extent to worry about, in view of the fact that new records were made in drilling last year.

The current discussion is part of the age-long controversy before Congress as to tariffs, subsidies, and price supports. On one side is the relatively small but insistent group of domestic producers whose welfare is hurt a great deal by free markets and absence of adequate tariff protection. Their investments and jobs may truly be wiped out, and the communities they support may become ghost towns. Protection is a vital matter to them. On the other side are the rest of the citizens of the country, enormously greater in number but comparatively disinterested because a few cents more or less that they pay for a few commodities does not affect them individually to any considerable extent. Only occasionally, such as when the Government buys up potatoes to keep the price up and then wastes them, does any considerable number of the common people protest.

Congress, being made up of all kinds of people, from those who place the business interests of large groups of their constituents first to those who are primarily interested in what is good for the country, or even the world, as a whole, usually winds up by adopting a middle ground.

In recent years there has been more of a tendency in the United States to break away from a local prosperity or nationalistic economy to the view that what is best for the country as a whole should be adopted. Further, that what is best for the world as a whole may well be best for the United States. This on the theory that peace, generally regarded as a *sine qua non* for the happiness of the country, is best assured by freedom of trade and higher standards of living in all countries. One of the leading spokesmen for this point of view is Sumner H. Slichter, Harvard business economist, whose lead article in the June *Atlantic*, "Our Best Defense", has aroused great interest.

Dr. Slichter points out some of the economic problems that the country must face in the next decade, and how the cold war with Soviet Russia can be handled. The two most important economic adjustments that must occur, he says, are a return of the prices of farm products to a long-term basis of demand and supply, and more equable conditions in our foreign trade. Three major trends must be halted, he believes: the rapid rise in government expenditures, the rapid spread of government intervention in business, and the drop in the influence of business men in the community.

Those who are against removal of tariff barriers, or favor increasing them, or who favor artificial prices to support domestic industries, will find little support in the Slichter article. For instance: "Substantial increases in imports of oil, iron ore, copper, lumber, and many foodstuffs would be in the national interest." "I do not assert that all of these regulations of the government are bad—though a few of them, such as the buying of silver, are completely bad, and others, such as the support of prices of farm products, are badly designed." "The discussion of the several problems . . . has indicated again and again the importance of two things: great increases in production and a large rise in imports."

New Oil Bonanza

If one turns to an ordinary atlas and tries to spot a certain county in Texas without the aid of an index he will find the job rather time-consuming for the Lone Star State has 264 such subdivisions, almost 100 more than the next most "countified" state of Georgia. However, in the western part of Texas the map is not too much cluttered up with towns and railroads and other evidences of civilization, so it is not too difficult to find Scurry County. In fact, its county seat, Snyder, stands out as more of a town than its 1940 population of 3815 would indicate. Lubbock, 80 miles to the northwest, was until a year and a half ago, much better known, but not now, at least among oil men. For Snyder is the center of a new boom, a new oil field that may rival the famous East Texas field. Its population has jumped to 30,000. Living quarters and public utilities are being hastily constructed and some 4000 trailers offer temporary homes.

No one knows how much oil there is underground but there are now some 700 wells producing from a reef formation 6000-7000 ft below the surface. Intelligent guesses indicate perhaps a billion and a half barrels of oil, more oil than was found in the first two years of East Texas, and more than has ever been found in Oklahoma, the fourth largest producing state in the Union. The field seems to be crescent-shaped, some 33 miles long at present, from its northeast extremity in Kent County, across Scurry County, to its southwestern end in Borden County.

AIME Personals

Howard W. Adam has left his post with Battelle Memorial Institute to go to Mulberry, Fla., where he is working for the International Minerals and Chemical Corp.

Herman E. Bakken becomes vice-president and general manager of the Aluminium Ore Co. on Aug. 1. He joined the ALCOA organization in 1919 and became associate director of the aluminum research labs. at New Kensington, Pa., in 1942.

Leon E. Battles has been promoted to chief engineer of iron mining operations in the Canisteo district of the Oliver Mining Co. **David H. Hill** has become assistant chief mining engineer at Coreraine, Minn.

Earle W. Berry has gone to Turkey where he is mill superintendent for Eti-Bank.

Lester F. Bishop recently became research engineer in charge of the Butte mining research department of the Anaconda Copper Mining Co. He was formerly research production foreman.

John R. Bogert has resigned his position with the Bethlehem Steel Corp. to return to college for graduate work in geology. He expects to be traveling through Europe visiting the various mining districts in July and August.

C. A. Botsford, who returned in December from mine examinations in India, Burma, and Siam, has gone to Rome as consultant for the ECA Italian Mission, with headquarters at the American Embassy.

Theodore T. Brooks has completed his work as assistant resident engineer on a large construction project of the Salt River Valley Water Users' Assn. in Phoenix. His new job is in California on a six month construction job as resident engineer for Leeds, Hill and Jewett, consulting engineers of Los Angeles.

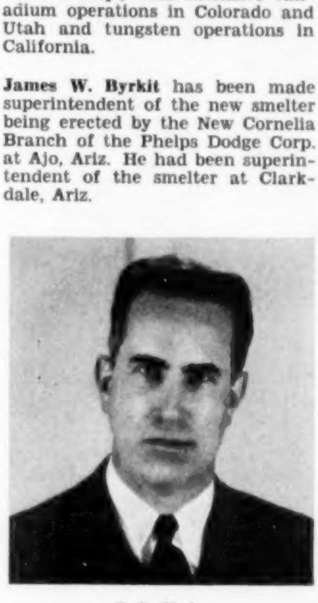
Arthur B. Caldwell has taken the job of engineer in training with the W. S. Rockwell Co., Fairfield, Conn.

Robert H. Carpenter, on leave of absence from the geology department of the Colorado School of Mines, has gone to San Juancito, Honduras, as consultant in charge of the geological examination of the Rosario properties of the New York & Honduras Rosario Mining Co.

Walter E. Remmers

Walter E. Remmers has been elected president of the U. S. Vanadium Corp., a unit of Union Carbide and Carbon Corp., with extensive vanadium operations in Colorado and Utah and tungsten operations in California.

James W. Byrkit has been made superintendent of the new smelter being erected by the New Cornelia Branch of the Phelps Dodge Corp. at Ajo, Ariz. He had been superintendent of the smelter at Clarkdale, Ariz.



C. D. Clarke

C. D. Clarke, after being associated with the Cia. Huanchaca de Bolivia, Pulacyo, Bolivia, for the past nine years, has resigned as general manager and is returning to the States with his family. Before returning, Mr. and Mrs. Clarke and their two sons are spending three months visiting England, France, and Italy. They expect to arrive in New York early in August.

Robert C. Cockrell has been employed by the mining department of the Republic Steel Corp., Southern Division, in Birmingham, Ala.

W. A. Coster has gone to Dutch Guiana as assistant superintendent of one of the bauxite fields of the Alcoa Mining Co.

Robert F. Devine has become assistant to the chief engineer of the Great Lakes Pipe Line Co. in Kansas City, Mo.

Walter J. Dezell, former foreman on the Kelley shaft at Butte, Mont., has gone to Conda, Idaho, where he will work in the fertilizer department of the Anaconda Copper Mining Co.

Marcus Digre has returned to Norway to become mill superintendent for the Sydvaranger Iron Ore Co. at Kirkenes.

Stanly A. Easton, president of the Bunker Hill & Sullivan Mining & Concentrating Co., received an honorary doctorate degree at the University of Idaho commencement exercises on June 5.

William H. Ebert has taken the job of mining engineer with the Kennecott Copper Corp. at Ray, Ariz.

Ernest G. Enck, secretary of the Foote Mineral Co., Philadelphia, recently returned from a trip to South Africa, Southern Rhodesia, Southwest Africa, and several European countries. He visited numerous holding and ore deposits of interest to the company and other sources of raw materials.

E. V. Faraggi has returned to his home in Paris since the Mercury Mines of Ras el Ma, par Jemmapes, Dept. de Constantine, Algeria, have been shut down because they can no longer produce mercury at a price competitive with Spanish and Italian mines.

C. S. T. Farish, of the Cerro de Pasco Copper Corp. in Peru, has been appointed general administrative superintendent. He was general superintendent of mines prior to this recent promotion.

C. A. Fredell recently resigned as manager of Cia. Minera Venturosa, Chihuahua, Mexico, and has joined the staff of the San Francisco Mines of Mexico, San Francisco del Oro, Chih., Mexico.

Rokuzo Furuichi has become president of the Imperial Mining Development Co. in Tokyo. He was chief engineer of Sumitomo-Goshikaisha, Osaka, Japan.

William F. Bates, June graduate of Penn State, receiving the Old Timers Club Award of a watch given to an outstanding senior in mining engineering, from L. C. Campbell, vice-president, Koppers Coal Div., Eastern Gas & Fuel Assn.

Elton W. Geist has left the employment of the National Lead Co. and is now associated with Telluride Mines, Inc., of Telluride, Colo.

William H. R. Gibney graduated from the University of British Columbia in May and took a post with the Consolidated Mining and Smelting Co. Ltd., at Kimberley, B. C.

C. E. Golson recently became associated with the Colorado Fuel and Iron Corp. in Denver as service and sales engineer, handling grinding media. His new address is 1745 W. 51st Ave., Denver.

Edward V. Hardy has been made assistant superintendent at the Garfield smelter of the American Smelting & Refining Co. He had been metallurgist in copper smelting.

John P. Herndon has become mine superintendent for the Anaconda British Guiana Mines Ltd., Georgetown, B. G.

C. R. Hilton has been made general manager and a member of the board of directors of Mount Isa Mines Ltd., Mount Isa, Queensland, Australia.

Patrick M. Hurley, assistant professor at MIT, has been appointed executive officer of the geology department there.

Edward F. Jacobson, Jr., has been employed by the Homestake Mining Co. in the training program.

T. L. B. Jepsen, since leaving Patino Mines and Enterprises, has accepted the post of assistant mill superintendent with Cia. Minera de Oruro in Colquiri, Bolivia. On Feb. 4, Mr. Jepsen and Gladys Lang were married in the Swedish Consulate in Oruro.

C. P. Keegel has accepted the management of the Cia. Minera Agua Fria, Honduras, C. A.

Cornelius F. Kelley, chairman of the board of the Anaconda Copper Mining Co., was awarded the honorary degree of Doctor of Commercial Science by the New York University School of Commerce, Accounts and Finance upon its 50th anniversary. The award was made to Mr. Kelley as one of the outstanding industrial, business, and financial leaders of the country.

W. F. Keyes, Jr., has been employed as assistant to H. A. Pearse, who is vice-president in charge of metallurgy and construction for the Howe Sound Co.

Carrel B. Larson, who for the past several years has been minerals attaché to the U. S. Embassies in several South American countries, recently accepted the position of assistant general manager of Patino Mines and Enterprises, Catavi, Bolivia.

Edward S. Frohling

Edward S. Frohling has been made plant metallurgist for the Climax Molybdenum Co. at Climax, Colo.

Esper S. Larsen has been made assistant chief geologist of the U. S. Bureau of Mines.

John P. Lowe is now associated with the Southwestern Engineering Co., 4800 Santa Fe Ave., Los Angeles.

Thomas Lyon retired recently as assistant to the general manager of the International Smelting and Refining Co. after being with the company for 28 years. He was made chief geologist in 1927 and took over the post he has resigned in 1944.

R. L. McCann, who has been assistant to the president of the New Jersey Zinc Co. responsible for the production of raw materials and finished products, was elected a vice-president of the company at the March directors meeting.

Sidney J. McCarroll has gone to Manila as chief engineer for the Philippine Development Co.

Donald H. McLaughlin, president of the AIME and of the Homestake Mining Co., gave the commencement address at the Michigan College of Mining and Technology exercises on June 5. Honorary degrees of Doctor of Engineering were conferred on Dr. McLaughlin, on **William M. Cameron,** vice-chairman of the Celanese Corp. of America, and on **Alex D. Chisholm,** general manager of the iron ore division of Picklands, Mather and Co. On June 9, Dr. McLaughlin delivered the commencement address at the Montana School of Mines and received another honorary doctorate in engineering.

Jan M. McShane, formerly assistant general manager of the Australian Gas Light Co. in Sydney, has become general manager of John McGrath Ltd., Sydney, which manufactures forgings, and merchandises steel and equipment, with particular interest in the earth moving, mining, and quarrying fields. Mr. McShane expects to visit the States this month.

A. E. Millar, formerly with the Inspiration Consolidated Copper Co. at Inspiration, Ariz., has gone to Chuquicamata, Chile, with the Chile Exploration Co.

James W. Morgan has been elected president of the Ayrshire Collieries Corp. to succeed **Robert P. Koenig,** who resigned to become president of Cerro de Pasco. Mr. Morgan had been vice-president and general manager of the Ayrshire group.

John P. Morgan has resigned as underground superintendent of New Occidental Gold Mines N. L. to accept the post of Reader (Associate Professor) in mining engineering at the University of Adelaide, S. Australia.

J. N. Org, is on his way back to Tsumeb, Southwest Africa, after a vacation in the States.

C. A. Paller is now associated with the Allied Dye & Chemical Corp., and can be reached in care of Semet-Solvay, Tralee, W. Va.

James P. Pollock, who was on the staff of the American Smelting and Refining Co., has become associated with the Northern Peru Mining Co., Casilla 57, Moquegua, Peru.

N. Prasad has been transferred to Patna, India, as mining expert and mines officer for the Bihar Government.

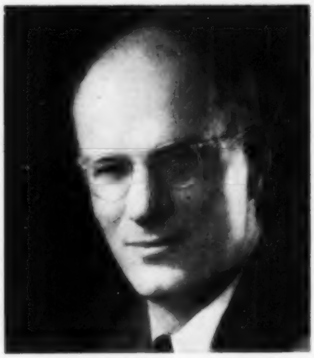
Graydon L. Salee has left his job as foreman in charge of the mill of the Cerro de Pasco Copper Corp. in Peru and is now with the Western Machinery Co. as a metallurgical engineer.

Donald E. G. Schmitt is now mine superintendent for Pamour Porcupine Mines Ltd., Pamour, Ont., Canada.

L. E. Snow has left the employ of the International Smelting & Refining Co. to become research engineer for the Utah Division of the Kennecott Copper Corp.

P. G. Sohnge was transferred on June 1 from the O'okiep Copper Co., Nababeep, to the Tsumeb Corp., Tsumeb, South West Africa.

Wallace E. Pratt, who was Anthony F. Lucas medalist in 1948, was awarded the Kemp Medal at Columbia University on May 4 for "Distinguished service in geology."



William B. Stephenson

William B. Stephenson has been elected vice-president in charge of sales of the Allen-Sherman-Hoff Pump Co. with headquarters in Philadelphia. Of his 13 years' connection with the Allen-Sherman-Hoff Co., he has served the last five years as sales manager of this associated company's pump division.

G. Douglas Strachan arrived in June in New York on his way to San Francisco after two years with the United States Philippine War Damage Commission in Manila, where he was responsible for the appraisal and adjudication of Philippine mine damage claims. Mr. Strachan intends to settle in San Francisco and can be reached there temporarily in care of AIME, 405 Montgomery St.

Glen C. Taylor has been transferred by the U. S. Gypsum Co. from Evans, Wash., to Nashville, Ark.

Robert J. C. Tait has accepted the position of testing engineer with Giant Yellowknife Gold Mines Ltd., Yellowknife, N.W.T. He was with Granby Consolidated Mining, Smelting & Power Co.

William E. Taylor has taken the post of metallurgist at the Oak Ridge National Labs., Carbide and Carbon Chemicals Div., Union Carbide and Carbon Corp., Oak Ridge, Tenn.

Hale C. Tognoni has a part-time job at the Carnegie Institute in the terrestrial magnetism division while attending law school.

Ted Toren is in Ciudad Bolivar, Venezuela, with the Oliver Iron Mining Co.

Jack B. Ward is visiting in the States on vacation from the Tsumeb Corp., Tsumeb, S. W. Africa. He will be at 2319 Victoria Drive, Laguna Beach, Calif., until Aug. 1 and then will return to Africa.

H. J. R. Way has been appointed director of the Swaziland Geological Survey, Mhabane, Swaziland, S. Africa.

Russell G. Wayland has been appointed acting U. S. Chairman of the Combined Coal Control Group, Office of the U. S. High Commissioner for Germany. The work remaining before the Group covers the approval and release of Marshall Plan funds to the individual development, construction, and reconstruction projects of the Ruhr coal mining industry, and the break-up of the corporate structure of old Ruhr combines and the establishment of new independent coal mining companies.

R. R. Weideman, who has been assistant to the manager of the Silver Dollar Mining Co., has been made manager of the company.

Thomas L. Wells, who has been associated with the North American Mines of Boston, for the last two years, is now engaged in independent consulting work with offices at 452 Fifth Ave., New York.

F. T. M. White has resigned from His Majesty's Colonial Mines Service and has accepted the appointment of professor of mining engineer in the University of Queensland, Brisbane, Australia. The chair is a new one and he is its first incumbent.

Jack White began his association with Kilembe Mine, Fort Portal, Uganda, E. Africa, on May 1.

Clarence T. Williams has become mine superintendent of the Kelowna Exploration Co., Nickel Plate, B. C., Canada.

J. P. Williams, Jr., has resigned as chairman of the board of the Koppers Co. and has taken up residence at his farm in Berryville, Va.

E. M. Platts

E. M. Platts has been elected executive vice-president of the Joy Mfg. Co. to succeed the late **Arthur S. Knoizan.** Mr. Platts joined Joy in 1945 when that company acquired La-Del Conveyor & Mfg. Co. of which he was vice-president. In 1947 he was elected to Joy's board of directors and placed in charge of all sales.

—Obituaries—

William Willard Taylor was erroneously listed in the obituary column of the June issue of Mining Engineering. Mr. Taylor is still very much alive. We sincerely apologize for any embarrassment or inconvenience this notice may have caused him.

Charles Bradley Andrews (Member 1936), assistant to the president of the Taylor Wharton Iron and Steel Co., died April 19. Mr. Andrews was born in Washington, D. C., in 1877, and received his A.B. degree from Princeton in 1898 and his M.E. from Cornell in 1902. He had been with Taylor Wharton for many years.

Frank Ashton (Member 1900), mining engineer of San Francisco, is dead. Born in England in 1861, he became a citizen of the United States in 1885. He became associated with the Consolidated Kansas City Smelting and Refining Co. in El Paso and then went to Mexico where he worked for many years.

John Moody Basham (Member 1940), consulting engineer of Shingle, Calif., died April 27. He was 61 years old. Mr. Basham earned his B.S. degree at the University of California. He worked for Pacific Mines, Silver King Coalition Mines, and the Mountain Copper Co. before the first World War in which he served as a Lieutenant in the Chemical Warfare Service. In 1919 he became mill superintendent for

Mountain Copper and was made general superintendent in 1934.

George Belchic (Member 1921), for many years a consulting mining engineer and independent oil operator, died Sept. 3, 1949. A native of Philadelphia, where he was born in 1890, he received degrees from Penn State and the University of Kansas. Consulting work took him to Missouri, Texas, and Louisiana. He was vice-president of Belchic & Laskey, Inc., of Shreveport.

Walter Wadsworth Bradley (Member 1929), for many years state mineralogist and chief of the division of mines, Dept. of Natural Resources, State of California, died April 11. Mr. Bradley had been an active member of the San Francisco Section for many years, serving as its chairman in 1935. He contributed several papers to AIME Transactions. Mr. Bradley was born in San Jose, Calif., in 1878 and received his B.S. and E.M. degrees from the University of California. He had worked for the Melones Mining Co. before beginning his association with the California State Mining Bureau as field assistant, statistician and curator. He became deputy state mineralogist in 1923 and state mineralogist in 1928.

George Sage Brooks

An Appreciation by F. O. Case

George Sage Brooks (Member 1908) died on April 16 in Ottawa, Ill. Born in New Bern, N. Y., in 1882, he studied at Michigan College of Mines. Mr. Brooks worked for the Mineral Point Zinc Co. and in 1919 joined the Anaconda Copper Mining Co. Under his leadership, Anaconda became a large factor in the U. S. zinc oxide pigment industry. In 1926 he was sent to Poland to direct the modernization and operation of the Polish Giesche Co. properties, continuing there until forced to leave in 1939 when Poland was invaded by Germany.

Sage Brooks leaves a host of friends who sincerely admired his unpretentious modesty, his keen interest in the world's literary and scientific activities, and above all his great consideration for and personal loyalty to his family, friends, and associates. As a leader in his profession he held the respect of his associates and coworkers and at the same time encouraged them to give their best that they might equal the high standard of accomplishment which he required. George Sage Brooks will be deeply missed by his many friends. All who were privileged to know him well were inspired by his personality, sterling character, and astute leadership.

Donald Wynn Crosby (Member 1944), owner of the Don Crosby Drilling Co. of Houston, died on Nov. 29, 1949. He was 43 years old. Mr. Crosby studied at the University of Oklahoma and in 1927 became production superintendent for the Navarro Oil Co. In 1937 he became president of the Wynn Crosby Drilling Co.

Francis Gordon Fabian (Member 1914), consulting mining engineer of Chicago, died Dec. 13, 1949. Mr. Fabian was born at Chicago in 1884 and was graduated from Cornell and Columbia. His first mining jobs took him to Costa Rica and Mexico but by 1913 he was back in New York as mining and consulting engineer with Fabian and Hall. He continued his consulting work in Chicago.

Edwin Scofield Giles (Member 1949), 78-year old mining engineer and land surveyor who was associated with gold rushes and mining camps since his arrival at Cripple Creek, Colo., in 1891, died Mar. 8. Born and educated in New York, Mr. Giles went West at an early age because of poor health. He became mine manager for the William A. Otis Co. He was actively connected with the Bullfrog and Pioneer booms. He named, surveyed, and lived several years at Pioneer, Nev. He was Nye County, Nev., surveyor and state water right surveyor.

Carroll Ralph Forbes

An Appreciation by Eugene A. Stephenson

Carroll R. Forbes (Member 1913) was born in 1882 and died suddenly Jan. 20 in San Gabriel, Calif. Following graduation from Michigan College of Mines, he worked for several copper companies. In 1909 he was appointed assistant professor of mining at Missouri School of Mines, becoming head of

the department in 1919. In 1941 he became production manager for the Baroid Division of National Lead, retiring in 1945.

As a teacher Carroll was almost without a peer. One of his unique contributions to teaching of mining was made in 1914 when he opened and developed on M.S.M. property, an experimental mine. Thereafter his students received practical mining experience. He also developed near the campus an open-pit mine from which many tons of diaspore were extracted for manufacturers of refractory brick.

The host of graduates who hold positions of responsibility in mining circles the world over, unite in tribute to their honored teacher.

Carroll Ralph Forbes

His readiness to assist them in academic or personal problems made him appear more like a fellow student than a detached professor. He was also their inspiration to high standards of achievement in both professional and private life, and as such his memory will long be cherished among those members of the mining fraternity who were so fortunate as to know him. To those of us who were his colleagues, he is remembered as a treasured friend and wise counsellor, with broad experience, sound judgment, and sterling character.

Charles Swanberg Hurter (Member 1923), retired explosives engineer, died Jan. 2 at St. Petersburg, Fla. He was born at Hyde Park, Mass., in 1875 and received an S.B. degree from MIT in 1898. He worked for various companies in the States and in Canada before becoming technical representative for E. I. du Pont de Nemours & Co. For several years he was with Hercules Powder Co., then returned to du Pont. Mr. Hurter contributed a number of papers to scientific magazines and lectured before many professional societies and at colleges.

Necrology

Date Elected	Name	Date of Death
1896	T. H. Aldrich, Jr.	May 26, 1950
1937	John H. Anderson	May 10, 1950
1937	John R. Bartlett	May 1950
1940	John M. Basham	Apr. 27, 1950
1908	George S. Brooks	Apr. 16, 1950
1897	Allan J. Clark	Unknown
1950	William H. Gabeler	Apr. 29, 1950
1924	Charles Hart	May 23, 1950
1930	H. M. E. Heinicke	Unknown
1893	W. L. Honnold	May 6, 1950
1928	Chambers Kellar	May 1950
1899	Clancey M. Lewis	May 17, 1950
1902	Mungo Park	Oct. 30, 1949

Joseph Hayward Jones (Member 1946), manager of the Westwood Colliery of the Stevens Coal Co., died April 18, at the age of 62. He had worked for P. & R. C. & I. W. engineering department in various jobs and was vice-president of C. K. Eagle & Co. He became manager of the Westwood Colliery in 1943.

William Adams Kissam (Member 1925), who retired three years ago as chairman of the board of the South American Development Co., died in January. Mr. Kissam, in 1896, was assistant treasurer of the South American Development Co., which was acquiring and developing gold mines in Ecuador. Two years later he became treasurer and went to Ecuador with the examining engineers to examine and purchase the property. In 1902 he was made president, directing the home office, reorganizing the companies, and raising funds for equipment. In 1905 he was president and treasurer of South American

Mines Co., holding company of South American Development.

David Allen Park (Student Associate 1948), who expected to receive his B.S. degree from the University of Alabama in 1949, died April 13, 1949.

Mungo Park (Member 1902), who was director of Park and Francis Ltd., mining engineers, Kuala Lumpur, Federated Malay States, died Oct. 30, 1949. Mr. Park, who was born in India in 1878, studied at the Royal School of Mines in London and the Imperial Mining Academy in Germany. He worked for the Halkyn Mining Co. in Wales.

James Goodell Parmelee (Member 1918), ore dressing engineer of Oakland, Calif., died last March. Mr. Parmelee had wide experience with numerous mining companies in the West and in Canada while earning his degree from Washington State. He had a fellowship at the University of Idaho in cooperation with the U. S. Bureau of Mines, and following that went to work for the Hardinge Conical Mill Co. He had also worked for Cerro de Pasco, and Bunker Hill & Sullivan.

John P. Shannon (Member 1937), vice-president of Snowden & McSweeney Co., oil producers of Fort Worth, Texas, died Dec. 28, 1949. Mr. Shannon was a director of the Mid-Continent Oil and Gas Assn., and of the U. S. Potash Co.

Ladislaus Szily (Member 1927), formerly with the Seaboard Oil Co., died on Feb. 20. An Hungarian by birth, Mr. Szily served in the U. S. Army in the Philippines during the Spanish American War and worked on the islands until 1904 when he went into the designing room of the N. Y. Central Rail Road. He was city engineer of Clovis, N. Mex., and was with Cia. Mexicana de Petroleo and the International Petroleum Co.

John Pendleton Wilcox (Member 1942), superintendent of the potash derivatives plant of the Potash Co. of America at Carlsbad, N. Mex., died Feb. 7. He had been with the Potash Co. since 1936. After graduating from Yale in 1927, he went to work for the Anglo Chilean Consolidated Nitrate Co. in Tocopilla, Chile, becoming acting reduction plant superintendent in 1933.

Oba Wiser (Member 1914), former consulting metallurgist for the Howe Sound Co., died Feb. 4. He had worked for Chino Copper, Republic Mining and Milling, Metals Exploration, and Britannia Mining & Smelting before becoming consulting metallurgist for Howe Sound in 1925. He retired in 1943, consulting for the company occasionally.

Proposed for Membership

MINING BRANCH, AIME

Total AIME membership on Mar. 31, 1950, was 16,397; in addition 4037 Student Associates were enrolled.

ADMISSIONS COMMITTEE

E. C. Meagher, Chairman; Albert J. Phillips, Vice-Chairman; George B. Corless, H. P. Croft, Lloyd C. Gibson, Ivan A. Given, F. W. Hanson, T. D. Jones, P. Malozemoff, Richard D. Mollison, and John Sherman.

Institute members are urged to review this list as soon as the issue is received and immediately to write the Secretary's Office, night message collect, if objection is offered to the admission of any applicant. Details of the objection should follow by air mail. The Institute desires to extend its privileges to every person to whom it can be of service but does not desire to admit persons unless they are qualified.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; AM, Associate Member; S, Student Associate.

Alabama

Bessemer—Talman, Woods G. (C/S—J-M).

Russellville—Craddock, Edmond H. (M).
Tuscaloosa—Clemmons, Ballard H. (M).

Arizona
Ray—Fiddes, Paul E. (J).

California
Oakland—Deleen, John L. (C/S—S-A).
Santa Monica—Baker, Arthur C. (M).

Colorado
Golden—Morgan, George B., Jr. (C/S—S-J).
Ouray—Lane, James L. (J).
Pueblo—Robertson, John, Jr. (C/S—S-J).

Massachusetts
Boston—Everts, Robert B. (C/S—J-M).

Minnesota
Crosby—Crist, Robert B. (M).
Duluth—Bailey, Charles N. (M). Borgeson, Oliver W. (C/S—S-J).
Hibbing—Sanden, Robert T. (C/S—S-J).

Missouri
Rolla—Schwartz, Ely. (J).

Montana
Butte—Embree, Francis P. (C/S—S-J). McElrath, Alden. (J).
Deer Lodge—Bell, Leslie V. (M).

Nevada
Tungsten—Jones, Robert B. (C/S—S-J).

New Jersey
Plainfield—Coss, Harold T. (M).

New Mexico
Albuquerque—Repenning, Charles A. (C/S)—S-J).

New York
East Aurora—Wood, Russell L. (C/S—S-J).
New York—Lynch, J. Joseph. (M).

Ohio
Middletown—Kingsbury, Chester L., Sr. (M).

Pennsylvania
Allentown—Hochberger, Samuel M. (R.C/S—S-A).
Bethlehem—Telfair, Peter. (R.C/S—J-A).
Pittsburgh—Morander, Harold G. (A).
Pottsville—Chesney, Francis W. (M).
Tamaqua—Price, Thomas F. (A).

Texas
Houston—Disbrow, Alan E. (J).

Utah
Bingham Canyon—Warner, Roland M. (M).
Magna—Shimmin, John T., Jr. (C/S—S-J).
Salt Lake City—Brennan, James T. (M).

West Virginia
Peach Creek—Cooke, William H. (M).

Alaska
Anchorage—Erickson, Walter A. (M).

Ontario
Schumacher—Urquhart, Martin L. (M).

Quebec
Noranda—Ballachey, Alexander G. (R—M).

Mexico
Picachos—Bush, Charles H. (R.C/S—S-M).

Peru
Casapalca—Forbes, John J. (J).

Australia
North Adelaide—Bosher, Peter A. (C/S—S-J).

Holland
Ryswyk—Seldenrath, Theodorus R. (M).

Philippine Islands
Surigao—Crenshaw, Ancel H. (M).

Portugal
Beira Baixa—Robb, Alastair H. (M).

Advertisers' Index

NEW PUBLISHING SCHEDULE

SPACE RESERVATION	— 1st	PRECEDING	MONTH
PLATES IN NEW YORK	— 7th	"	"
MAGAZINE ISSUED	— 23rd	"	"

* Previous Issues

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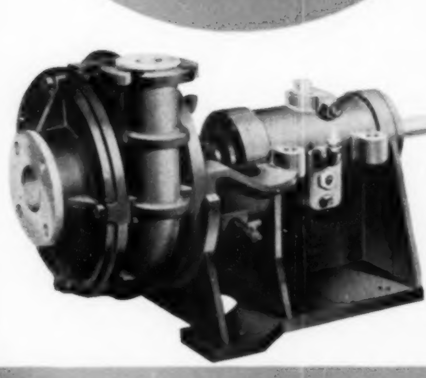

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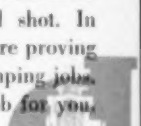

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